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The Plains Garter Snake, *Thamnophis radix*, in Ohio

By Roger Conant, Edward S. Thomas, and Robert L. Rausch

THE announcement that *Thamnophis radix*, the plains garter snake, occurs in Ohio and is not rare in at least one county, will surprise most herpetologists and students of animal distribution. Since the publication of Ruthven's monograph on the genus (1908), almost all authors have followed his definition of the range of this species, giving eastern Illinois as its easternmost limit. Ruthven (p. 80), however, believed that *radix* very probably would be found in western Indiana, a supposition since substantiated by Schmidt and Necker (1935: 72), who report the species from the dune region of Lake and Porter counties.

There may be other stations for *radix* in Indiana, but concrete evidence is lacking. We recently canvassed all members of the American Society of Ichthyologists and Herpetologists who live in that state, but none of them had encountered *radix* there. Hay (1881: 738) recorded a specimen which he *believed* to have been taken at Irvington (the italics are ours), and Cope (1888: 400) based his *Eutaenia radix melanotaenia* (a synonym of *radix*) upon a snake that, reputedly, came from Brookville. We have been unable to locate the specimens on which either of these records were based. The Brookville locality, lying in the Illinoian drift of the extreme southeastern part of Indiana, is open to question, particularly since other species (*Heterodon simus* and *Hyla squirella*), whose ranges probably never included southeastern Indiana, have also been reported from the same town. The snake catalogued in the United States National Museum (No. 25951) as *radix* from Honey Creek, Vigo County, is actually *Thamnophis ordinoides elegans*, hence obviously there has been an error either of bookkeeping or of locality.

Thus, while *radix* is known from the Indiana dunes and may occur elsewhere in that state, no one previously has reported it from Ohio—no one except the late Raymond L. Ditmars. In his *Reptile Book* (1907: 223), and again in 1936 (p. 141), he gives the range as "western Ohio to the eastern slopes of the Rocky Mountains," and one of the three *different* ranges he gave for *radix* in 1939 (p. 223) is the same. While this statement has been generally ignored, it is possible that Ditmars may have received an Ohio *radix* early in his career. Specimens constantly were being sent to him for identification from all over the country.

There is now adequate proof that *radix* does occur in Ohio. We are able to present data from fourteen specimens, nine of which have been preserved. These are listed in the order in which they were collected.

1. 2 miles SW of Upper Sandusky, Wyandot County, July 18, 1931 (TMS 767). Found dead on the road by Conant.
2. Southwestern limits of Marion, Marion County, March, 1937. An extremely large specimen, estimated to be nearly 1000 mm. in length. Collected by Rausch.
3. West of Marion, Marion County, spring, 1937—Rausch.
4. Section 33, Grand Prairie Township, Marion County, June, 1937—Rausch.
5. Western outskirts of Marion, Marion County, April, 1938—Rausch.
6. Section 26, Big Island Township, Marion County, September 2, 1940 (OSM 535). Collected by Thomas.
7. Clark's Bridge (over the Scioto River), Montgomery Township, Marion County, May 18, 1941—Rausch.

8. Section 6, Greencamp Township, Marion County, June 28, 1941 (OSM 536)—Rausch.

9. Section 7, Marion Township, Marion County, April 12, 1942 (OSM 537)—Rausch.

10. Section 6, Greencamp Township, Marion County, May 31, 1942 (OSM 538)—Rausch.

11. Section 5, Marion Township, Marion County, June 27, 1942 (OSM 539)—Rausch.

12. Greencamp Township, Marion County, August 15, 1942 (ANSP 24735)—Rausch.

13. Section 9, Pitt Township, Wyandot County, August 24, 1942 (OSM 667)—Darius Washburn and Thomas.

14. Section 7, Pitt Township, Wyandot County, April 25, 1943 (OSM 670)—Washburn and Thomas.

Letters and numbers in parentheses indicate preserved specimens and their respective museums and catalogue numbers. Toledo Museum of Science No. 767, the only specimen available for study prior to the publication of the *Reptiles of Ohio* (Conant, 1938), was therein described in some detail (p. 103) as an aberrant *Thamnophis s. sirtalis.* The junior author first recognized the presence of *radix* in Ohio and it is his persistent and successful efforts that have brought together a series of specimens.

The scutellation of the preserved snakes is as follows:

No.	Sex	Scale Rows	Ventrals	Subcaudals	Labials	Oculars	Temporals	Total Length in mm.	Tail Length in mm.	Tail Length/Total Length
ANSP 24735	♂	19–21–19–17	156	75	7–10	1–3	1–2	512	129	25.2%
OSM 538	♂	19–21–19–17	158	76	7–10	1–3	1–2	329	78	23.7%
OSM 667	♂	19–21–19–17	154	75	7–10	1–3	1–3, 2	463	113	24.4%
OSM 535	♀	19–21–19–17	155	44†	7–10*	1–3*	1–2*	757†	124†	—
OSM 536	♀	19–21–19–17	153	65	8–10	1–3, 2	1–2	431	93	21.6%
OSM 537	♀	21–19–17	151	28†	8–10	1–3	1–2, 3	603†	70†	—
OSM 539	♀	21–19–17	152	66	8–10	1–3	1–2	400	88	22.0%
OSM 670	♀	19–21–19–17	149	18†	8–10	1–3	1–2	524†	50†	—
TMS 767	♀	19–21–19–17	151	64	7–10	1–3	1–2	645	137	21.2%

* Head partially crushed; counts could be made only on left side.
† Tail incomplete.

In all particulars these scale counts fall well within the limits of variation given for *radix* by Ruthven (*op. cit.*).

All are quite similar in coloration and pattern. A composite description (from life) follows: Middorsal stripe bright orange yellow, occupying the median row of scales and adjoining fractions of the adjacent rows. Lateral stripe bright yellow; situated on scale rows 3 and 4. Dorsal ground color dark chocolate brown. A double row of round black spots on each side of body between the stripes, these approximately 1 to 1½ scales in length and about 2 to 2½ scales in height; the spots often run together and thus obscure the ground color. A row of similar dark spots between the lateral stripe and the ventrals. Belly light greenish grey, each ventral with a conspicuous black spot at each end; sutures between the ventrals often irregularly bordered with black. There is a tendency in some specimens for spots on adjacent ventrals to run together. Similar, but indistinct, markings on the under side of the tail. Top of head and occipital region black or very dark brown, except for a pair of bright yellow parietal spots. Lower labials, chin, and throat uniform pale yellow; sutures between lower labials edged with black in some specimens. Upper labials yellow, their posterior edges broadly bordered with black, especially toward the rear of the head. There are yellow or yellowish areas on the nasals, preoculars, and lower postoculars.

All nine preserved Ohio specimens have been compared with *radix* from Illinois and other parts of the range; in general appearance and details of pattern they are in agreement.

Persons using the key in the *Reptiles of Ohio* will find that *Thamnophis radix* will check out to section 9 (p. 20). It differs from all other Ohio garter snakes, however, in having a maximum of 21 scale rows (the others have 19); both *radix* and *Thamnophis s. sauritus* have the light lateral stripes on the 3rd and 4th scale rows, but *radix* has a short tail—26% or less of the total length as compared with 28% or more in *sauritus*.

It should also be noted that *radix* has a relatively large and wide head which is considerably different in shape from the narrow head of *sauritus* and the noticeably small head of *butleri*.

Of the several specimens we have collected alive some were in the open, sometimes on the prowl; others were hidden beneath various objects as indicated in the section on ecology. Almost all flattened their bodies considerably when they were alarmed or handled, and most of them struck and attempted to bite repeatedly. Those kept captive ate live earthworms, frogs, minnows, and chopped fish.

Ecology [1]

It is of considerable interest to note that this population of a western species, a great number of miles to the east of any previously known station, should occur in what was once the most extensive single wet prairie area in Ohio. It also is noteworthy that this snake has been able to survive drastic alteration of its former habitat. The original prairie, now some of the most productive farm land in the state, has been almost completely destroyed by cultivation and grazing, and the former prairie vegetation is at present limited to remnants along the roadsides and railroad rights of way and to a few restricted swales which have proved difficult to drain.

The specimens from the immediate vicinity of Marion were taken along railroads, particularly the New York Central System. The rights of way of these are paralleled by broad shallow ditches which, having never been plowed or grazed, support a luxuriant growth of prairie vegetation, probably not differing greatly from that which prevailed originally. Among the characteristic prairie plants occurring there may be mentioned the prairie dock (*Silphium terebinthinaceum*),[2] sawtooth sunflower (*Helianthus grosseserratus*), white wild-indigo (*Baptisia leucantha*), prairie cordgrass (*Spartina pectinata*), big bluestem grass (*Andropogon furcatus*), prairie lily (*Lilium michiganense*), and many others.

The Big Island Township specimen came from a cultivated field a few hundred feet from the New York Central tracks.

The specimen from Marion Township, Section 7, was found in a shallow prairie swale (dry throughout most of the year) which appeared to have been undisturbed by man in recent years. Among the characteristic plants growing there are the cordgrass, wild-indigo, common reed-grass (*Phragmites communis*), Virginia mountain-mint (*Pycnanthemum virginianum*), wild bergamot (*Monarda fistulosa*), scattered saplings of *Crataegus*, and such common

1 The discussion of systematics in this paper has been contributed principally by Conant and Rausch; that on ecology principally by Thomas and Rausch.

2 Technical names of plants are those used in Deam's *Flora of Indiana*, the only up-to-date manual generally available.

weeds as teasel (*Dipsacus sylvestris*), common cinquefoil (*Potentilla canadensis*), Kentucky bluegrass (*Poa pratensis*), American germander (*Teucrium canadense*), smooth oxeye (*Heliopsis helianthoides*), Virginia wild-rye (*Elymus virginicus*), and the foxglove beard-tongue (*Penstemon digitalis*).

The locality in Marion Township, Section 5, is an ancient channel of the Little Scioto River, now far removed from the bed of the present stream. It contains water throughout most of the year but becomes dry during the summer months. It appears to have been grazed severely over a long period of time, as is evidenced by the presence of extensive colonies of water smartweed (*Polygonum hydropiper*). There is, however, a dense growth of marsh vegetation, including a few species that are characteristic of prairie swales. Among the conspicuous plants may be mentioned swamp rose (*Rosa palustris*), gray dogwood (*Cornus racemosa*), wing-angled loosestrife (*Lythrum alatum*), dark-green bulrush (*Scirpus atrovirens*), fogfruit (*Phyla lanceolata*), marsh yellow-cress (*Rorippa palustris*), ditch stonecrop (*Penthorum sedoides*), and marsh pea (*Lathyrus palustris*).

One of the specimens from Greencamp Township was taken from beneath a log in a pasture a few rods from an extensive swale which is an old oxbow of the Scioto River; the second one was found at the border of some sedges. The swale is filled with water except in the driest part of the year. It contains a sizeable colony of buttonbush (*Cephalanthus occidentalis*), and is bordered by a number of black willows (*Salix nigra*). In spite of heavy pasturing, there is a good growth of marsh vegetation in and around it. There are dense stands of sedges—*Carex* spp. and of dark-green bulrush and mild smartweed (*Polygonum hydropiperoides*). Other characteristic plants are lake watercress (*Armoracia aquatica*), spatterdock (*Nuphar advena*), marsh purslane (*Ludwigia palustris*), ditch stonecrop, swamp persicária (*Polygonum coccineum*), and fogfruit. No characteristic prairie or prairie swale vegetation remains, if it were ever present.

The snake from Pitt Township, Section 9, was discovered beneath a shock of oats while the crop was being harvested. The field borders the Sandusky River and is close to a rather extensive prairie swale which shows no evidence of having been plowed or grazed. Part of the swale had been burned some months previously and was covered at the time it was visited with a dense growth of fireweed (*Erechtites hieracifolia*) and Pennsylvania persicaria (*Polygonum pennsylvanicum*). There are scattered, scrubby specimens of shingle oak (*Quercus imbricaria*) and of *Crataegus* spp. around its border and even invading the swale. In places there are dense stands of tall sedges, cordgrass, and big bluestem, and several colonies of the tall, robust river bulrush (*Scirpus fluviatilis*). Such characteristic prairie plants as glaucous spiderwort (*Tradescantia canaliculata*), sawtooth sunflower, and Virginia mountain-mint are also present.

During the threshing operations, in addition to the foregoing specimen, four common garter snakes (*Thamnophis sirtalis sirtalis*) and one massasauga (*Sistrurus catenatus catenatus*) were captured.

The specimen from Pitt Township, Section 7, was found near the grassy margin of a small artificial pond in the midst of a cultivated field. It is situated in an excellent example of black-land prairie, but cultivation has destroyed every vestige of the original vegetation.

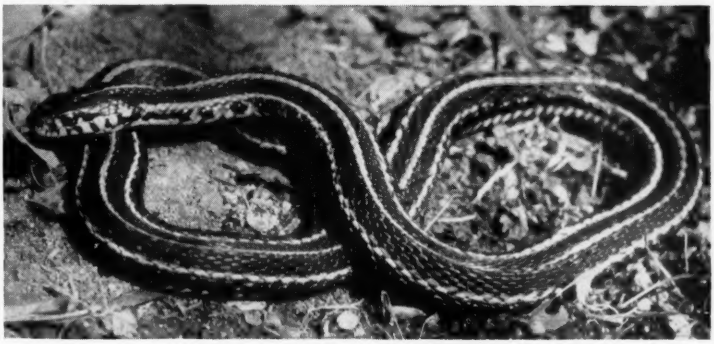


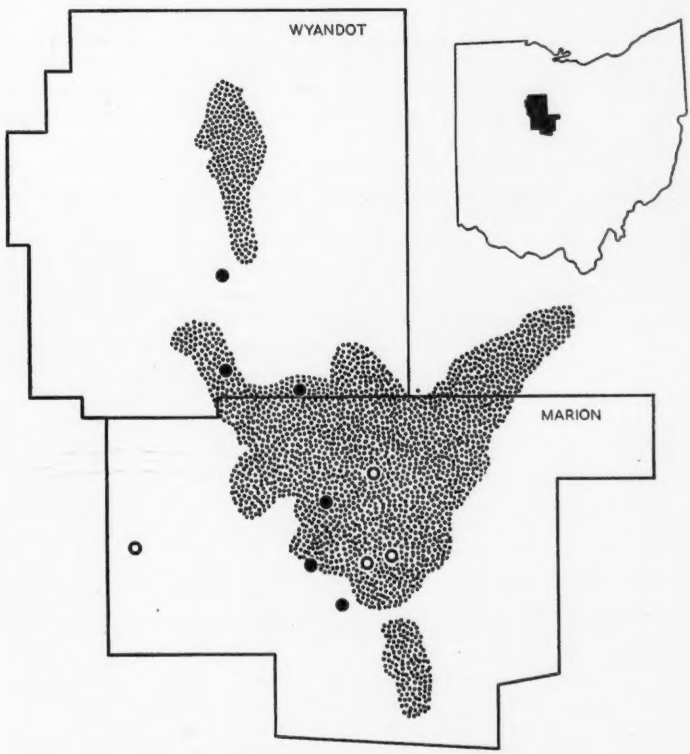
Fig. 1. Adult female specimen of *Thamnophis radix* collected April 12, 1942, in Section 7, Marion Township, Marion County, Ohio. Color characters are helpful as field recognition marks. The bright orange dorsal stripe and the bright yellow lateral stripes contrast strongly with the dark areas between them. In *radix* there are extensive black maculations on the labials, types of markings which usually are not well developed (if present at all) on the labials of *Thamnophis sirtalis,* the only other snake with which *radix* is very apt to be confused. The head of *Thamnophis butleri* is, proportionately, very small; *Thamnophis sauritus* has a narrow head and a long tail. (See text for details.)

Photographs by Edward S. Thomas.

Fig. 2. The Little Scioto River in Section 5, Marion Township, Marion County, Ohio

Fig. 3. A swale occupying an old oxbow of the Scioto River, Greencamp Township, Marion County, Ohio.

All of the foregoing localities are in the midst of a typical, flat, wet prairie country with deep, black soils and sluggish mud-bottomed streams. Few of the specimens of *radix,* however, were captured in typical prairie land. It will be noted, rather, that all were in, or close to, prairie swales or streams. This was also true of the Montgomery Township specimen, which was found on the bank of the Scioto River. No evidence of prairie habitat was noted in the vicinity, but the river at this place has all the aspects of a typical prairie stream; it is deep and sluggish, with few riffles and with mud banks and bottom.



Map 1. Stations for *Thamnophis radix* in Ohio. Solid circles represent preserved specimens; hollow circles represent additional specimens which were not preserved. The stippled areas show the approximate extent of relict prairies in Marion and Wyandot counties (adapted from Transeau, 1935). The portion of Ohio in which the two counties are situated is indicated on the smaller map (upper right). Maps prepared by Edmond Malnate.

The presence of this western snake in the prairies of Ohio, so far east of any other known colony, would seem to constitute one of the most remarkable

examples of prairie relict yet recorded. There is always the possibility, of course, that it may have been introduced by human means in historic times, but this seems unlikely. Its very wide distribution throughout the prairie area of western Marion and southern Wyandot counties would indicate that the species has been established in the region for a long time.

Schmidt (1938) has given an admirable review of a number of prairie relict amphibians and reptiles, postulating that these species extended their range from the western prairies following the retreat of the ice in post-Pleistocene times. He follows many European writers in the opinion that the invasion of our present prairie fauna and flora followed closely after the retreat of the ice, steppe (prairie) succeeding tundra.

There is, indeed, some evidence of a xeric period coincident with or immediately following the last retreat of the Pleistocene ice sheet, as is indicated by Sears' (1942b) review of the European literature. Many European, as well as American, writers, however, find evidence of a much more recent and more pronounced xerothermic period. The analysis of pollens at various profiles of boreal relict bogs indicates the concurrence of five climatic periods in post-glacial time: (1) A moist, cool period, with a maximum of fir and spruce; (2) A dry, probably warmer period (the "Boreal" of Sernander, 1911) with a maximum of pine often mixed with oak (that this period was not extensive or pronounced in North America, however, is indicated by the fact that evidence of it is wanting in many American profiles); (3) A more humid, also warm period (the "Atlantic") with a maximum of beech and, in places, of hemlock; (4) A warm, dry period, the Xerothermic Period or "Subboreal," with a maximum of oaks and hickories and a minimum of beech; and (5) The present (probably cooler and with more available moisture than in No. 4). So far as the Prairie Peninsula is concerned, Transeau (1935) has shown that a prairie-like climate still obtains throughout the region, in contrast with the areas to the north, south, and east of the Peninsula.

While there is evidence, in Europe at least, of a considerable extension of steppe species in the Boreal Period, following close after the glacial retreat, it would seem entirely unnecessary to go back so far to account for the present-day prairie fauna, especially in view of the abundant evidence of a pronounced Xerothermic Period in fairly recent geologic time. In fact, it is evident that the warm, humid Atlantic Period, which preceded the Xerothermic, would have been distinctly unfavorable for the survival of any prairie elements which might have come east earlier. Sears (1942a), has shown that during the warm, humid maximum, beech extended its range as far west as Iowa, far beyond its present distribution, while hemlock spread extensively over areas where it is not now present. Both these species of trees are pronounced mesophytes. Similarly, Wilson and Webster (1942) offer fossil evidence of a wider range in Wisconsin of such mesic species as butternut and hickory than now prevails. If the climate during this period was sufficiently humid to have resulted in the wide dispersal of such mesophytic plants, the inference follows that any prairie elements remaining from an early post-Pleistocene invasion must have been adversely affected, if not completely extirpated, and that we must consequently look to the comparatively recent Xerothermic Period to account for the eastward extension of our present prairie flora and fauna into the prairie Peninsula.

It seems likely that *Thamnophis radix* invaded the eastern portions of the Prairie Peninsula during the Xerothermic Period along with other characteristic prairie plants and animals. There it exists today, in isolated prairie relict communities. In view of the apparent rarity of the species, it must be more exacting in its requirements than other more widely distributed and locally abundant prairie species of plants and animals. At the same time, in this region in Ohio, where it occurs in good numbers, it has proved tolerant to changed conditions brought about by agricultural practices.

The distribution of *Thamnophis butleri* presents an entirely different pattern from that of *Thamnophis radix* and other prairie relict plants and animals which are believed to have extended their ranges eastward during the Xerothermic Period. The stations for *radix* appear as disjunct colonies extending like a tongue from the western prairies eastward into the Prairie Peninsula, the colonies tending to become more and more isolated as they approach the eastern tip of the Peninsula.

Thamnophis butleri, on the other hand, is endemic to the eastern part of the Prairie Peninsula and, except for an isolated Wisconsin population, is not known west of the Illinois-Indiana line. It, too, may be considered as a relict of a former climate, since it exists in isolated colonies throughout most of its range. It seems altogether likely, however, that *butleri,* unlike *radix,* existed prior to the Wisconsin glaciation somewhere near its present range, as postulated by Schmidt (*op. cit.*). Persisting throughout Wisconsin times beyond the periphery of the ice sheet, it may have spread into the glaciated portions of the Prairie Peninsula soon after the retreat of the ice.

It is entirely possible that *radix* will be found in additional prairie or prairie-like areas in other parts of Ohio. It may also be found to occur in Michigan, as is suggested by a specimen (ANSP 6226) labelled "Michigan" and collected by Dr. Miles. It evidently was thought to be *sirtalis* when caught and it was so catalogued until recently. Judging from the frequency with which *radix* and *sirtalis* have been confused, one of the most promising places to search for *radix* might be in preserved collections of *sirtalis!*

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ZOOLOGICAL SOCIETY OF PHILADELPHIA, PENNSYLVANIA, OHIO STATE MUSEUM, COLUMBUS, OHIO, AND MICHIGAN STATE COLLEGE, EAST LANSING, MICHIGAN.

The Embryonic Appearance of Centres of Ossification in the Bones of Snakes

By MALCOLM A. FRANKLIN [1]

RELATIVE to the general interest of the group, there have been few embryological studies in snakes. An attempt is made in the present paper to find a routine method of obtaining a complete series of embryos, and as a contribution to the study of osteogenesis in snakes, to determine the stage in which the earliest centres of ossification appear in each bone. The order of development of the centres of ossification in the snake embryos is compared with that of a chick as described by Lillie (1919).

METHODS AND MATERIALS

The species examined were the brown water snake (*Natrix taxispilota* Holbrook); the banded water snake (*Natrix sipedon pictiventris* Cope), obtained from Florida; and the hog-nosed snake (*Heterodon contortrix* Linnaeus), the ring-necked snake (*Diadophis punctatus punctatus* Linnaeus), and the green snake (*Opheodrys vernalis* Harlan) obtained near University, Mississippi. The water snakes were used because of their large size and the

[1] I wish to acknowledge the suggestion of the present problem by Dr. Charles A. Evans, and the aid and advice of Dr. D. S. Pankratz, Department of Anatomy, and of Dr. R. P. Walton, Department of Pharmacology, in the progress of my studies.

large number of eggs produced by each female. Embryos of the hog-nosed snake were obtained by incubating the eggs artificially. The method used was similar to that used by Reese (1901) in incubating alligator eggs. Nine eggs were placed in a box of damp humus to prevent them from drying and covered very lightly with damp leaves. The box was then placed in an incubator at a temperature of 37°C. Four of the eggs proved to be infertile, two eggs were allowed to hatch, and three of the eggs were opened at different stages of development. The eggs of the ring-necked snake, found under a rotting log, contained embryos almost ready to hatch. One was killed immediately and used for study; the other was allowed to reach maturity. They were regarded as fully developed although there was still a mass of unabsorbed yolk 10 mm. in diameter protruding from the abdominal wall.

The method of obtaining embryos by caesarian section from live-bearing snakes as described by Clark (1937), was employed with some modification. The large size of the water snakes made them excellent subjects for caesarean section. They were on an average 4½ feet long and 8 inches around the abdomen. Each snake carried approximately 30 embryos, of which two or three were taken at each operation until the embryos reached full term. Some of the snakes were operated on as many as nine times. The gestation period of the brown water snake varies apparently from 68 to 75 days. The lengths and ages of the embryos of this species at 25 successive stages are as follows:

Stage	Length	Age	Stage	Length	Age	Stage	Length	Age
1	2 mm.	5 days	10	58 mm.	25 days	18	98 mm.	36 days
2	6 mm.	8 days	11	61 mm.	26 days	19	119 mm.	41 days
3	8 mm.	10 days	12	64 mm.	27 days	20	140 mm.	46 days
4	13 mm.	12 days	13	69 mm.	28 days	21	142 mm.	47 days
5	24 mm.	15 days	14	70 mm.	29 days	22	155 mm.	49 days
6	34 mm.	18 days	15	83 mm.	33 days	23	187 mm.	57 days
7	38 mm.	20 days	16	89 mm.	34 days	24	202 mm.	61 days
8	49 mm.	23 days	17	94 mm.	35 days	25	250 mm.	73 days
9	53 mm.	24 days						

The breeding season of the snake is the latter part of May and the young are born in the first part of August. They are born out of water and are about 11 inches in length at birth. It was noticed that shortly after parturition the young molt, after which they are very active.

For the caesarean operations a suitable anesthetic was sought. Ether was first tried but was found to be impractical because of difficulties in its administration. The "open drop ether" was the only method that could be used with even partial success on the snakes. The third stage of anesthesia was found difficult to obtain and to maintain satisfactorily for a period of time. Some of the snakes died from what appeared to be reflex cardiac ventricular fibrillation during the second stage of anesthesia and others died from respiratory paralysis. The difficulty of giving artificial respiration in these experiments also made ether impractical. Certain barbiturates were then tried and sodium pentobarbital (Nembutal) proved to be the best of the group. Sodium phenobarbital, sodium barbital, and sodium amytal were also used successfully in anesthetizing the snakes, but the use of these barbiturates is inadvisable on account of the long recovery time, that for sodium phenobarbital

being approximately 90 hours, for the sodium barbital 48 hours, and for sodium amytal 36 hours.

A 1% solution of sodium pentobarbital in physiological saline or distilled water was used and the dosage was 1cc per 400 grams of body weight.[2] The sodium pentobarbital was injected intraperitoneally, approximately in the middle of the abdomen, great care being taken not to puncture any of the large blood vessels around the oviduct. It required from 30 minutes to an hour and a half for the snakes to become anesthetized and from 15 to 24 hours to recover from the anesthetic. The dosage used in these experiments is approximately the same as the intravenous dosage used in most mammalian experiments, which is 25 milligrams per kilogram of body weight.

The caesarean operations were done under aseptic conditions. The operative technique itself consisted of the exposure of the oviduct by a longitudinal abdominal incision about an inch and a half in length and near the position of the most anteriorly situated embryo, just below the gall bladder, a point about midway of the body length of the snake. The oviduct was then opened with great care in order to avoid cutting any of the large blood vessels surrounding the oviduct. After the oviduct was opened two or more embryos were removed, the others being left to continue normal development. The oviduct and peritoneum were then sutured with catgut (no. 00; 20 day), and the abdominal incision closed by pressing the fleshy surfaces together and securing them at the base of each ventral scale by a stitch of strong linen thread. The wound was then dressed with a sterile dressing. The use of wound clips did not prove successful because after recovering from the anesthetic the snakes pulled the clips out by crawling about in their pens. Further incisions were made at intervals, progressively farther backward until all embryos had been removed. These operations can be repeated at intervals of about 2 days. One brown water snake was operated on 5 times in succession and two weeks later gave birth to 22 young. Thus the operative procedure apparently did not affect the development of the remaining embryos.

Although the operations were done under aseptic conditions and the snakes were kept in clean cages, about half of the individuals developed infections. To overcome the difficulty, powdered sulfanilamide and sulfathiazole were dusted over the peritoneum and surrounding tissues while the incision was being closed. If after this procedure the snakes developed infections, the wounds were thoroughly cleaned and dusted with either sulfanilamide or sulfathiazole every 12 hours. This proved very effective and greatly reduced the percentage of snakes lost from infection. Sulfathiazole proved to be much the more effective, and the use of sulfanilamide was discontinued. The use of sulfathiazole evidently did not impair the development of the embryos.

For the study of ossification the embryos were cleared and stained by the method of Dawson (1926) for staining the skeleton of cleared specimens with Alizarin Red S (Sodium Alizarin Monosulphonate) with slight modifications of the procedure. The specimens were fixed in 10 per cent formalin for 72 to 96 hours. Longer fixation tended to make the tissue more difficult to clear. The embryos were then washed in iodine alcohol for 24 hours, and transferred to a solution of 3 per cent potassium hydroxide in which they remained until the bones of the skull and the ribs were clearly visible through

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[2] The dosage used by Clark (1937) was 1cc per 60 gm. body weight.

the surrounding tissues. The cleared specimens were then stained in a solution of Alizarin Red S, one part alizarin to 10,000 parts 1 per cent KOH. The stain was allowed to act until the desired intensity was attained. After the embryos had been stained, they were placed in Mall's solution (1 part KOH, 20 parts glycerine, 79 parts water) to complete the clearing process. When sufficiently cleared, they were passed up through increasing concentrations of glycerine and stored in pure glycerine to which a crystal of thymol had been added to prevent the growth of mold.

For the study of osteogenesis, 34 different embryonic stages of the brown water snake were examined. These were compared with nine stages of the banded water snake, four stages of the embryo hog-nosed snake, two hatchling ring-necked snakes, and a single mature green snake. The stained specimens were examined with a wide field binocular microscope and a hand lens. The embryos were examined in clear glass dishes using transmitted light. By this method the earliest centres of ossification could be located with little difficulty.

Osteogenesis

The histogenesis of the bone in snake embryos appears to be similar to that of the chick as described by Lillie (1919), although there is a marked difference between the two in the time and in the order of ossification. According to Lillie, ossification of the clavicles, long bones, and membrane bones of the skull in the chick are well advanced before ossification begins in the vertebrae, the first centre of ossification appearing in the clavicle; deposits of alizarin are found in the axis of the membranous rods on the eighth or ninth day. In the brown water snake the first signs of ossification were found in the centra of the first cervical vertebrae, and these appeared on the 25th day. Other vertebrae show signs of ossification almost simultaneously. The centrum is endochondral. As with the chick it was found that the progress of ossification is antero-posterior.

No new centres of ossification were found in the snake embryos until the 27th day, when centres of ossification appeared in the palatine and pterygoid bones of the skull, both membrane bones. The appearance of additional ossification centres is quite rapid until the 41st day, when the last bones to develop in the embryo make their appearance. On the 28th day of gestation, early centres were found as minute red deposits of alizarin red in the suprangular bone of the skull and also in the neural arch. The suprangular bone and neural arch were both membranous in origin. The first bone of the skull with an endochondral origin to appear was the exoccipital. This bone along with the various membrane bones, the dentary, vomer, pre-maxilla and angular were found to show centres of ossification on the 29th day. On the 33rd day ossified centres were located in the proötic, nasal, and prefrontal, and there was a slight deposit of stain in the posterior part of the parietal, alizarin was also found in the splenial, frontal, squamosal, and a very faint trace of stain was present in the transversum, which became definite on the 34th day, when the maxilla had begun to ossify. On the same day the costal ossification centre of the rib was located. This was seen as a long thin deposit of alizarin along the middle portion of the rib. The origin of this centre of ossification is endochondral. On the 35th day of development the quadrate and post frontal bones were found to show early centres of ossification. Centres were also seen

in the articular and coronoid bones of the lower jaw on the 36th day. On the same day the neural arch was found fused and the neural spine or spinous process showed signs of ossification. The last primary centres of ossification appeared in the bones of the brown water snake on the 41st day. On this day centres of ossification were present for the first time in the basioccipital and parasphenoid bones and in embryos of a slightly greater length the basisphenoid and supraoccipital bones showed early deposits of alizarin. Along with these centres there were faint traces of stain in the haemal process. After this stage of development no more primary centres of ossification were found, although not until the snakes reached early maturity was ossification of all the bones completed.

In the full-grown green snake ossification of all the bones appeared to be complete. In the hatchling ring-necked snake a few of the bones of the skull and the heads of the ribs were incompletely ossified.

Comparison of the embryos of the ring-necked snake, hog-nosed snake, and banded water snake with those of the brown water snake demonstrated very little difference in the time and order of the first signs of ossification centres. In the few specimens available for study the embryos of the banded water snake ran directly parallel to those of the brown water snake. The same was true of the embryos of the hog-nosed snake except in the centres of the maxilla, the nasal, and the vomer, which appeared at an earlier stage than the same centres in the brown water snake. The ribs at the same period of development were also developed to a greater extent. The specimens of the hatchling ring-necked snake and hog-nosed snake were found to be more completely ossified than in the fully developed water snakes.

The origin of the skull bones in *Natrix taxispilota* is as follows:

angular	membrane	postfrontal	membrane
articular	endochondral	prefrontal	membrane
basioccipital	endochondral	premaxilla	membrane
basisphenoid	endochondral	prootic	endochondral
coronoid	membrane	pterygoid	membrane
dentary	membrane	quadrate	endochondral
exoccipital	endochondral	splenial	membrane
frontal	membrane	squamosal	membrane
maxilla	membrane	suprangular	membrane
nasal	membrane	supraoccipital	endochondral and membrane
palatine	membrane	transversum	endochondral and membrane
parasphenoid	membrane	vomer	membrane
parietal	membrane		

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Further Observations on Louisiana Captive Snakes

By George P. Meade

LONGEVITY OF *Lampropeltis triangulum amaura.*—Information as to the life span of snakes, especially of the smaller forms, accumulates slowly. Major S. S. Flower has summarized all the records known to him of life span of vertebrate animals in a useful set of papers published in the *Proceedings of the Zoological Society of London* (1925–1937). Of the harmless snakes listed, a garter snake was credited with 11 years and a pilot blacksnake with 14 years, these being the longest periods that individuals of these American species were known to have lived. In general 20 to 29 years was the life span of the longest lived large snakes. Pope (1937: 28) points out that the records seem to indicate that pythons live longer than the smaller snakes, but that this may be because the smaller snakes are more easily replaced and hence do not receive the care afforded the larger pythons and boas. However, Pope cites a note by Schumann of a European leopard snake that lived in the Sofia Zoo for 25 years, the longest known life span for any snake. As the leopard snake (*Elaphe situla*) is seldom more than a yard in length, Pope concludes that a generalization on the relationship between long life span and size of species is unwarranted for snakes.

No records are given for the very small species and it is therefore of interest to report on two specimens of *Lampropeltis triangulum amaura* in my collection, one of which died on July 22, 1944, after 12 years in captivity. The second snake, which has lived for 9 years in the same portable cage (12" x 15" x 12") with the first one, is still in excellent condition.

Notes on the life history and habits of these relatively rare "scarlet king snakes" were reported some years ago (Copeia, 1940: 165). At that time it was stated that from the size of these two snakes when captured (14 inches and 10 inches respectively) and of several others that have been in my possession, it was inferred that the older snake was two years old when captured and the younger, one year old. Based on these conservative assumptions, the snake that died may have been 14 years old and the second is now thought to be 10 years old. Both snakes, as reported previously, are females.

The older specimen was 23½ inches long at time of death, having gained only 2½ inches in 5 years. It was quite slender (about one-half inch in diameter) but not emaciated, and had fed regularly on *Anolis* to the last week. For a year and a half (since March, 1943) this snake had shown no visible tongue motions whatever. When this was first noticed it was believed that death would soon follow but there appeared to be no change in feeding habits or in health and condition up to the end. Especially noticeable was the ease and regularity of moulting, as remarked in the previous article. The gentle, quiet disposition of this snake throughout its long captivity was in direct contrast to that of the surviving cage mate, which is nervous and irritable and resents handling.

Notes on *Lampropeltis elapsoides elapsoides.*—An interesting addition to my collection of these harmless mimics of the coral snake is a true scarlet king

snake, *L. e. elapsoides,* captured near Baton Rouge on Christmas Eve, 1941. This beautiful little 5-inch snake was plowed up in a field on a cold day and evidently was in its first year. At present, in its fourth year, the length is about 12 inches. The brilliant red snout is in sharp contrast to the gray-black snout of *amaura,* and the coloration generally is more vivid.

This specimen has fed readily on skinks from the time of its capture, refusing to take even small specimens of other lizards until quite recently. The feeding preference continues to be for skinks. Schmidt and Davis (1941: 173) say of the scarlet king snakes, "Captives are gentle, rarely attempting to bite," but this one has always been pugnacious and invariably bites when handled.

Additional Evidence of Maternal Care of Eggs by *Farancia.*—Indications of maternal care of eggs by *Farancia* were reported by myself in 1940 (1940a: 15). The mother snake coiled about the clutch of eggs for seven weeks following the laying, leaving the eggs on several occasions to feed, to moult or to defecate and returning to them with the apparent purpose of incubating or protecting the eggs. Photographs of snake and eggs on the date of laying and six weeks later accompanied that report. A similar occurrence with rather more striking evidence of maternal care was observed in the summer of 1944.

On July 14, a large female *Farancia abacura reinwardtii* (about 62 inches long and quite heavy bodied) laid twenty-two eggs and remained coiled about them as in the previous instances. (See also Copeia, 1937: 12.) Snake and eggs were first covered with a moist cotton sugar sack and then with an inverted galvanized iron pan for protection against sun and rain. The eggs were laid in the same open cage with earthen floor as in the case previously reported and the pan was placed so that the snake could crawl out from under it readily. The following day the snake had placed herself on top of the edges of the cloth with the eggs under the center part so that the eggs were completely and securely covered. The effect was as if the snake were coiled about the brim of a cloth hat with the eggs in the center under the crown. The result was as accurately achieved as if the shaping of the cloth and covering of the eggs had been done by hand. For the next four weeks, the succession of events followed the previous case closely. The snake left the cloth-covered eggs several times, always moulting and defecating as far from the eggs as the size of the cage would permit. The edges of the cloth were well flattened and it was at least three weeks before the hat-like form was disturbed sufficiently so that a few of the eggs were exposed. The snake was removed three times in the four weeks to feed on *Amphiuma* and each time after being replaced in the cage she was found coiled about the eggs on the following day. The eggs remained sound throughout this period with no evidence of attack by mildew, ants or maggots. In artificial incubation in this region, eggs must be carefully protected to prevent attacks by these three destructive agencies.

On August 18 the cage was flooded with rain and the eggs dispersed. The snake appeared to lose interest in them so after two days they were removed and placed in a jar for artificial incubation. In the next few days, several were found to be infested with maggots and were discarded and mildew attacked most of the rest until only two were left. These two hatched about September 20.

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The Individual Range of Some Florida Turtles [1]

By LEWIS J. MARCHAND

INFORMATION as to the wanderings of individual turtles within their home range, their growth under normal conditions, and their population density may best be obtained by a system of marking individual turtles and making systematic efforts to recapture the specimens. I have been engaged for some time in the study of the natural history of Florida turtles, and have employed a method of search by swimming under water in the crystal clear waters of the great springs of central Florida, described in a previous note in COPEIA (1945). Marking has been by the method of Cagle (1939), using a hand-drill. Some results of studies made in 1940-1942 are here summarized.

DATA FROM CRYSTAL SPRINGS

Crystal Springs are a group of springs in Pasco County, Florida, forming a short run of about 75 yards which then joins the Hillsborough River. The river, below the junction with the spring run, is normally clear, from 15 to 35 yards in width and from 3 to 12 feet deep. The dominant plant is

[1] A contribution from the Department of Biology, University of Florida.

Chara sp., although in the short spring run water purslanes (*Isnardia* sp.) and southern water cress (*Cardamine curvisiliaqua*) are particularly abundant. Bonnets (*Nymphaea* sp.) are found grouped in beds along the banks.

Turtles are very numerous here. *Pseudemys f. peninsularis* is the most abundant form, while another member of the genus, *P. nelsoni,* is moderately common. The common stink-jim (*Sternotherus odoratus*) is found in great numbers, while *Kinosternon b. baurii* is occasionally seen. The chicken turtle (*Deirochelys reticularia*) is the least common testudinate inhabitant of the river, only two individuals having been marked. This situation is the type locality of *Pseudemys f. peninsularis.* It is an excellent locality in which to study the wanderings of individual pseudemyd turtles, since the river is small and locality records can be exact, and the clarity of the water permits the use of water goggles in observing and capturing the turtles. I selected as an area to be surveyed for use in the study about a half-mile of the river, from the springs downstream, and terminating at a swimming resort on the east bank. The east side of the river in this area has a moderately high bank, and along this runs a trail much used by fishermen, while the other bank of the river is low and swampy.

It was found that the turtles are not active during the mid-day hours, and are to be found hiding along the edges of the stream, with heavy concentrations at such places as caves, fallen trees and bonnet patches. The annual flooding to which the river is subject washes out most of the aquatic plants, and after these periods the turtles are to be found with increased frequency in these areas of refuge. This habit of the population was an advantage, since most of the hiding places were known and an examination of them permitted an observation of the majority of turtles in the area. The help of my wife greatly facilitated the recording of the recapture of specimens. I swam down the stream searching the favored hiding places of the turtles, while she kept pace with me along the bank, making notations of each return on a map. I carried a small hand drill with which to mark any new turtle, which usually could be done by standing on the creature in shallow water, and drilling underwater. The first turtles were marked on March 24, 1940, and the last returns obtained on March 22, 1942. Heavy rains kept the river in almost continual flood stage the second year, consequently most of the returns were obtained during the first year.

Total numbers of specimens marked were as follows: 151 *Pseudemys f. peninsularis,* 12 *Pseudemys nelsoni* and 2 *Deirochelys reticularia.* Of the *Pseudemys f. peninsularis,* 33 individuals were retaken once, 8 individuals twice, 3 individuals were retaken three times, and one individual was retaken four times. Thus, returns were obtained for 45 specimens, or 30% of the individuals marked. No *Pseudemys nelsoni* were retaken, and only one *Deirochelys reticularia.* Of the 33 *Pseudemys f. peninsularis* which were retaken once, 16 had not moved. Six of these returns were within a month, while the greatest length of time elapsed was 7 months (2 cases). Of the 17 individuals which did wander, 8 moved 100 yards or less, and the greatest distance covered was 300 yards (3 cases; 7 months, 1½ months, and 7 days, respectively). In the group of eight specimens which were retaken twice, the greatest distance from the original point was 265 yards, this in a period of

one month. Two individuals had not moved at all, and two returned to the site of initial capture. In the group of three specimens with three returns, two showed attachments for certain places, while the third wandered extensively, covering 400 yards in 19 days, although the total distance from the starting point was only 225 yards. The turtle that was retaken four times had not moved on one occasion, and the maximum distance covered on any movement was 175 yards, this in 18 days. The solitary *Deirochelys* which was retaken showed a movement of 670 yards in slightly more than 8 months.

Data from Rainbow Run

During the period 1940–1942 I obtained data on growth of turtles in Rainbow Run, a large, clear calcareous stream in Marion County, Florida. Locality records were only occasionally kept, but 20 returns were obtained, equally divided between *Pseudemys f. peninsularis* and *Pseudemys f. suwanniensis,* and of these 14 had wandered 700 yards or more. During the entire period of my study marked turtles were common in the lower portion of the run, a distance of about 5 miles from the point of release. Some of this wandering should probably be attributed to abnormal population pressure set up by releasing large numbers of turtles at one point on the run.

Conclusions

From the results obtained at Crystal Springs, it may be said for that locality that the normal range of the *Pseudemys* population probably does not exceed 300 yards (which distance could be easily covered by an individual in a single day). The results obtained at Rainbow Run seem to indicate that the normal range of the turtles may to a certain extent be correlated with the areal extent and character of the environment. Here a wandering of several miles was a not uncommon occurrence, while at Crystal Springs the range is measured in hundreds of yards. The possible error involved in the data from Crystal Springs is contributed by the limited extent of the area studied; turtles remaining inside this area were consistently recaught, while those moving out were missed. However, the relatively good number of the turtles that were recaught (30%), and the failure of the individuals to wander over the entire area studied leads me to believe that the conclusions drawn relative to the range of *Pseudemys* in this region are essentially correct. It is possible that at Rainbow Run the few days captivity prior to release induced the turtles to wander more, while the individuals at Crystal Springs, released immediately after capture, were not thus abnormally stimulated.

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Seasonal Variation in the Mental Gland and Reproductive Organs of the Male *Eurycea bislineata*

By Charles K. Weichert

The males of several genera of plethodontid salamanders possess a glandular patch on the chin. Dunn (1926) describes this mental gland only in *Desmognathus* but Noble (1927), who has assigned a hedonic function to the structure, mentions it as being best developed in *Oedipus, Hydromantes* and *Eurycea*. Noble (1929) states that among other secondary sex characters, the presence of the mental gland may be used to distinguish male from female *Eurycea* from October to May and possibly longer. The secretions of this hedonic gland, together with those from smaller glandular areas on the eyelids, jaws, neck and temporal region, apparently serve to attract and excite the female during courtship when the snouts of the two sexes are rubbed against each other.

The material presented in this paper concerns observations on the cyclic changes in the mental gland and reproductive organs of the male plethodontid salamander, *Eurycea bislineata bislineata* (Green), preliminary to some experimental studies on its endocrine system.

Materials and Methods

Mature specimens were collected once each week for an entire year. All animals were secured from the same locality along approximately 500 yards of a small stream-bed in Mt. Airy Forest near Cincinnati, Ohio. Animals collected in their natural habitat should be of more value in determining variations in structure than specimens kept under artificial conditions in terraria in the laboratory.

Observations on the temperature of the air and soil where the animals were found were made on each collecting trip. The animals were always found in moist situations and under cover.

The living specimens were brought to the laboratory, anesthetized in chloretone and then fixed *in toto* in Bouin's picro-formol. After remaining in the fixative overnight, the animals were run up through a series of alcohols to 80% alcohol in which they were preserved for further study. Altogether 555 animals of both sexes were collected and preserved. A single large, mature male was selected as representative of the week's collection and the mental gland, vas deferens and a testis were removed for sectioning. Sections through the largest portion of the testis were selected always as being most advanced, so far as stages in spermatogenesis were concerned. Spermathecae of representative mature females were sectioned regularly in order to obtain information concerning the times when spermatozoa are present in the female.

Ecological Observations

In the Cincinnati area the breeding season of *Eurycea bislineata* is limited to the end of March and first two weeks in April. It was only during this time that adult specimens were found in the water. At all other times of the year the animals were found in moist situations sometimes at a considerable distance from the stream-bed.

In general, the salamanders were situated in places that were somewhat lower in temperature than the air. This was true except during cold weather when the animals were found in the soil below the frost line and at a temperature just above the freezing point. On the contrary, during the hot, dry, summer weeks, specimens were found at a temperature considerably lower than the air. The most favored location during such times was in densely packed masses of moist leaves. The highest temperature recorded for the soil in which the animals were found was 76°F., whereas the lowest was 33°F.

The stomach contents of at least one animal from each week's collection were examined. Unless digestion had progressed too far, identification of the food was made. This included small wood-roaches, spiders, ticks, earthworms, isopods, millipedes, beetles, small snails of the genera *Physa* and *Planorbis,* grubs, springtails and a variety of dipterous and hymenopterous insects. It was astonishing to find food in the stomach during every week of the year with one exception. In the last week of January only two animals were collected, neither of which had any food material whatsoever in its stomach. The data indicate that during the warmer months when plenty of food is available, the stomachs almost invariably contain food. As cold weather approaches and the animals are about to hibernate, the stomach is full. The food is apparently digested slowly during the hibernation period. A warm spell during the cold winter may activate the animals to forage for food. Recently swallowed food was found in the stomachs of animals collected on cold days in February when preceded by one or more warm days.

Anatomical Observations

Mental Gland.—To distinguish the sexes in the field, the mental gland was generally used as a criterion. This structure, when well developed, may easily be seen through the skin of the lower jaw. During April it became increasingly difficult to determine sexual differences by this method and by the end of April was no longer possible. A decided retrogression of the mental gland occurred at this time and not until the middle of August did it again enlarge sufficiently to be noticed externally.

Study of the prepared slides of the mental gland (Figs. 3, 6, 9, 12) showed that within two or three weeks after the breeding season the gland had undergone a marked recrudescence and it remained in the retrograde condition throughout the summer. Beginning early in August it began to hypertrophy and continued to enlarge. The cells of the tubules first began to secrete actively around the first of November (Fig. 12). They were distended with secretion throughout the entire winter and remained so until the breeding season, in late March and early April, was past.

Vas Deferens.—The vas deferens of *Eurycea bislineata* is a long, convoluted duct leading from the anterior end of the testis to the cloaca. It is intense black in color. The duct is lined with a single layer of cuboidal epithelium.

By the end of April, although a few spermatozoa remained in its lumen (Fig. 5), the vas deferens had become markedly reduced in size and by the middle of May was in a "resting" condition (Fig. 8). Growth began once more around the middle of August and by the middle of September spermatozoa again entered the vas deferens. At the end of September the duct was

very large and engorged with masses of spermatozoa. It remained in this condition throughout the winter (Fig. 11) but reached a maximum degree of distension during the breeding season (Fig. 2).

Testes.—By the end of February, considerably before the advent of the breeding period, but few spermatozoa remained in the testes and new spermatogonia from the walls of the testicular lobules were developing. At the end of the first week in March all spermatozoa had left the testes and the lobules appeared to be solid masses of spermatogonia (Fig. 1). The vasa deferentia were, at this time, distended with spermatozoa.

From the middle of March to the end of May (Fig. 4) the testes underwent but little change. Early in June the spermatogonia began to go through the growth period incident to becoming primary spermatocytes. About the middle of July the primary spermatocytes were in the spireme stage preliminary to the first maturation division. Spermatids first appeared during the last week in July and first week in August (Fig. 7) but it was not until the end of August that completely formed spermatozoa were again found in the testicular lobules. Spermatozoa did not appear in the vasa deferentia until three weeks later. By the end of September spermatogenesis had been completed and the testicular lobules were filled with spermatozoa arranged in dense clusters with their heads in intimate relation with the Sertoli cells (Fig. 10). No apparent change occurred during the winter months.

Spermathecae.—The spermathecae of the females contained remnants of spermatozoa for somewhat over a month after the eggs had been laid. No spermatozoa were found in any female throughout the summer months. In specimens collected at the end of October or first part of November and throughout the winter months, spermatozoa were found to be present in the spermathecae of most, but not all, of the females.

Discussion

Finding spermatozoa in the spermathecae of the majority of females almost five months before the breeding period, is contrary to the report of

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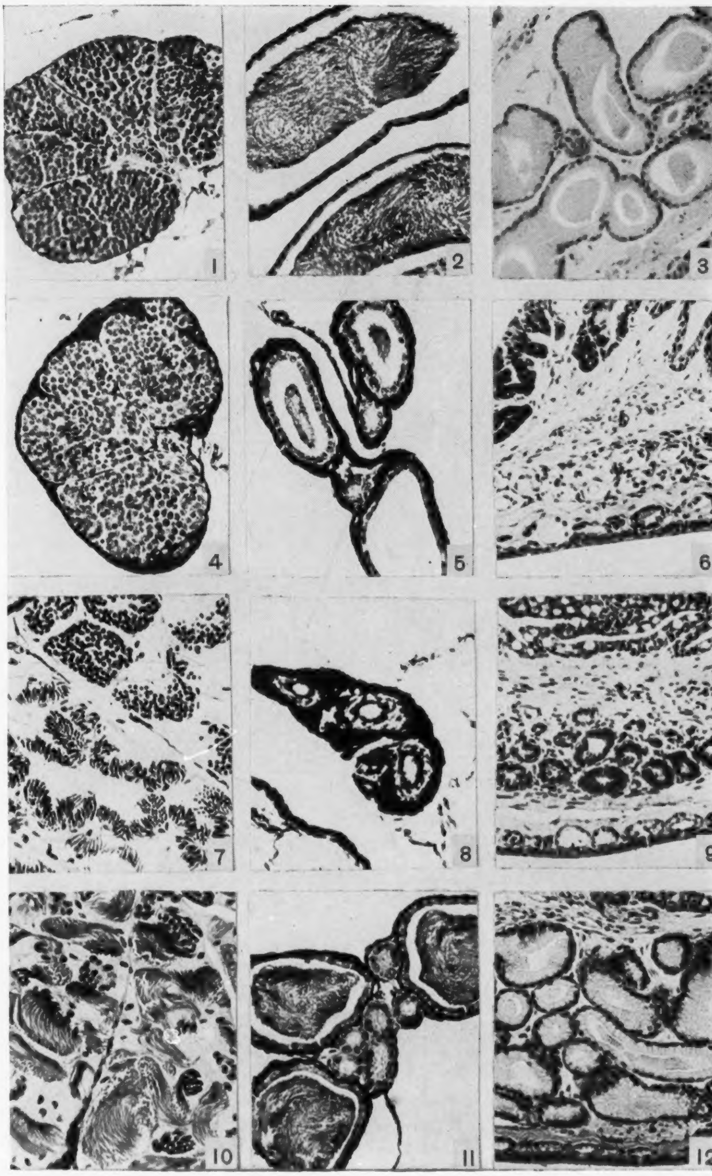
Plate I

Figs. 1, 2 and 3. Sections of testis, vas deferens and mental gland of male *Eurycea b. bislineata* collected April 4 during the height of the breeding season. Only spermatogonia are present in the testis which has been emptied of spermatozoa at least three weeks prior to this date. The testis remains in this condition until near the end of May. Vas deferens and mental gland show their maximum degrees of development.

Figs. 4, 5 and 6. Sections of testis, vas deferens and mental gland of male *E. b. bislineata* collected May 2, about two weeks after the breeding season has passed. The testis shows little, if any, change over the condition during the height of the breeding period. Retrogression of the vas deferens has progressed considerably and but few spermatozoa remain. The mental gland has undergone a marked recrudescence.

Figs. 7, 8 and 9. Sections of testis, vas deferens and mental gland of male *E. b. bislineata* collected August 11. Activity in the testis is indicated by the presence of spermatocytes and spermatids. The vas deferens is still in a "resting" condition but growth will begin in about two weeks. The mental gland shows renewed activity.

Figs. 10, 11 and 12. Sections of testis, vas deferens and mental gland of male *E. b. bislineata* collected Nov. 2. It is at this time that the "autumnal mating" or "false breeding season" occurs. The testis is fully developed, the vas deferens contains large numbers of spermatozoa and secretion has appeared in the tubules of the mental gland. Neither vas deferens nor mental gland are so fully developed as they will be during the true breeding season at the end of March and beginning of April.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Koehring (1925) who states that "the mating of *Eurycea* takes place in the spring. There have been no spermatozoa found in the spermatheca during the fall and winter months." The present observation indicates that a period of courtship must take place around the end of October or early November. It is precisely at this time that the cells of the mental gland begin to secrete actively. These findings emphasize the important part which the mental glands must play in the mating behavior of *Eurycea* since mating is seemingly in abeyance until the mental gland is properly developed. An "autumnal mating" or "false breeding season" similar to that of *Eurycea* has been reported for *Triturus viridescens* by Gage (1891), Jordan (1893), and Adams (1940). The latter investigator has found spermatozoa in the spermatheca of *Triturus viridescens* in every month of the year. In this respect *Triturus* differs from *Eurycea*. No ovulation has been observed in either *Eurycea* or *Triturus* until the spring breeding period.

In *Eurycea bislineata* spermatogenesis begins early in June and progresses slowly until the end of August when mature spermatozoa are first found in the testes. Early in August, however, the mental gland begins to develop. This activity first occurs at the time that spermatids are being formed in the testes. The vas deferens, on the other hand does not begin to grow until about two weeks later. Adams (1940) reports that in *Triturus viridescens* the onset of development of the secondary sex characters occurs at the time when spermatids are transforming into spermatozoa.

The testes of amphibians have long been known to be responsible for the development of male secondary sex characters (Steinach, 1894, 1910; Nussbaum, 1909; Bresca, 1910). However, the site of male hormone elaboration in amphibian testes has been the subject of considerable controversy (Champy, 1921; Aron, 1921, 1924; Humphrey, 1921, 1925). Humphrey (1925), from his studies of *Triturus viridescens,* believes that development of secondary sex characters is initiated by changes either in the germ cells themselves or in the related Sertoli cells. The present observations are in agreement with those of de Beaumont (1933), Rodgers and Risley (1938) and Adams (1940), who argue that the testicular hormone in urodeles is first produced at a time when the germinal cells of the testes are undergoing active spermatogenesis.

Regardless of the source of the hormone, it would appear that in *Eurycea* the mental gland reacts earlier in response to testicular hormone than does the vas deferens. Whether this involves a difference in threshold, is a matter for further investigation.

Although by the end of September the testis is in a static condition so far as spermatogenesis is concerned, the mental gland continues to undergo development. The maximum state of development does not occur until March. Likewise, the vas deferens, although containing masses of spermatozoa, continues to grow throughout the winter and reaches the climax of its development simultaneously with the mental gland.

The testes are emptied of spermatozoa at least a month before the breeding period and these cells are stored in the vas deferens. The presence of spermatozoa in the testes cannot be correlated with the maintenance of the mental gland and vas deferens in their maximum states of development, for these latter structures even increase in size after all sperm cells have been liberated from the testes. The fact that the vas deferens and mental gland

retrogress shortly after the breeding period, despite the presence of some spermatozoa in the vas deferens, is presumptive evidence that the presence of these cells alone is not responsible for the maintenance of secondary sex characters. This evidence lends support to the contention of Aron (1921, 1924) that the sperm cells themselves are not the source of hormone production in the testes of amphibians.

The seasonal changes observed in the testes of *Eurycea bislineata* are in general accord with those reported for a number of other species of salamanders (Spengel, 1876; Heidenhain, 1890; Kingsbury, 1902; Nussbaum, 1906; Wright and Allen, 1909; Kingsbury and Hirsch, 1912; Champy, 1913, 1922; Humphrey, 1921, 1922, 1925; Aron, 1924; de Beaumont, 1929, 1933; McCurdy, 1931; Carrick, 1934; Burger, 1937; Rodgers and Risley, 1938; Adams, 1940).

In the present study one is impressed with the fact that although the breeding period of *Eurycea* does not take place until late March and early April, the reproductive systems of both male and female are fully developed several months before this time. Noble and Richards (1930, 1932), by administering pituitary transplants, have induced female *Eurycea* to lay fertile eggs in November, December and January. The relationship of the gonadotrophic hormones of the anterior pituitary gland to the gonads of both sexes has been demonstrated by a host of investigators for many vertebrates. The factors which operate in nature to awaken the animals' own pituitary gland to activity remain obscure.

Variations in the number of hours of daylight to which animals are exposed has been shown by many workers to have profound effects upon the reproductive systems of several vertebrates. Others show no modifications. Among amphibians only the African clawed toad, *Xenopus laevis,* has been reported to be affected by changes in the daily duration and intensity of light (Zwarenstein and Shapiro, 1933; Shapiro and Shapiro, 1934).

It would seem that variation in the food supply is of little, if any, importance in causing the changes observed in *Eurycea* since ample food was found in the stomachs of specimens collected during practically every week in the year.

It is interesting to note that the reawakening of cellular activity in the testes, vasa deferentia and mental gland of *Eurycea* occurred as the temperature of the air and soil approached the maximum of the summer. Much further work on the relationship of environmental factors to the reproductive system in amphibians must be carried on before any definite conclusions regarding causative factors are warranted.

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A Method of Estimating Minimum Size Limits for Obtaining Maximum Yield [1]

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TWO well-known American fishery biologists, W. C. Herrington and R. A. Nesbit, have recently (1944) presented the advantages and disadvantages of various methods of regulating fisheries for maximum yield, in a discussion which should be read and re-read by everyone having an interest in that subject. Though their views diverge on some matters, both investigators are agreed that minimum size limits, where technically feasible and biologically desirable, should have a high priority among possible conservation measures. This means that the determination of what constitutes a desirable minimum for each fishery should have equally high priority on investigation schedules. At the present time factual data from which desirable size limits could be accurately determined are available for very few North American fisheries (at least insofar as such data are published). But we may look forward to substantial progress in the not-too-distant future as the value of the informa-

[1] Contribution No. 343 from the Department of Zoology, Indiana University.

tion becomes more widely recognized. It is timely therefore to present a brief review of the kinds of data needed in such work, how they may be obtained, and also the method of calculation which, to the writer at least, seems to give the most accurate determination of the best minimum size.

Herrington and Nesbit, and others before them, have pointed out that the key to the solution of most problems of fishery regulation is to be sought in a comparison of the rates of growth and of mortality of the fish, throughout their life history. Typically, young fish grow rapidly from the time they hatch until some months or years have elapsed. Mortality may also be heavy during this time, but growth exceeds death and the net result is that the year-class increases greatly in bulk, having begun with only what substance was contributed by the eggs. Obviously this increase cannot continue indefinitely, and sooner or later growth rate decreases, or mortality rate increases, to the point where the net weight of the year-class begins to decrease. Once started, the decrease typically continues at an accelerating rate, until finally the last survivor dies. We are faced then with two opposed phenomena, the rate of growth and the rate of mortality of the year-class; the difference between these two at successive instants in the past, plus the original weight of fry hatched, determines the present contribution of each year-class to the total population.

Growth in fishes of temperate regions is a seasonal affair, particularly in fresh waters. It is natural to expect that mortality too should, to a great extent, vary seasonally in approximately the same manner, at least insofar as it results from such things as disease, senility or the activities of cold-blooded predators—all of which are affected by temperature. Where warm-blooded predators are an important cause of mortality, this may well be as heavy in winter as in summer: for example, some commercial fisheries operate all year round, and cases are on record where fish-eating birds cause heavy losses in limited environments in winter.

Whether or not mortality and growth are fairly well synchronized, the only practical method of analysis appears to be to treat them as though they were so, at least as a first approximation. Growth in fishes is usually studied from annual marks on scales or other hard parts, and as ordinarily done it gives the length only once a year. Similarly estimates of mortality rate, as a rule, will give the numbers present only at yearly intervals.

To strike a balance between growth and mortality it is essential that they both be expressed in terms which can be compared readily. The best unit is the *instantaneous* (also called logarithmic, exponential or elemental) rate of growth, here represented by k, and the instantaneous rate of mortality, i. Any base and any period of time could be used to define the numerical value of these statistics, but in most work the base $e = 2.7183$ is used, and a year is the usual unit of time. On this basis, if the fish which survive to the end of a year have increased in weight by the fraction b over what they weighed a year earlier, the instantaneous rate of growth k of the year-class can be found from the expression:

$$e^k = 1 + b \qquad (1)$$

Similarly, if a year-class decreases in numbers by fraction a in a year, the instantaneous rate of mortality i can be found from:

$$e^{-i} = 1 - a \qquad (2)$$

The principal justification for making the transformation to instantaneous rates lies in the fact that the net instantaneous rate of increase or decrease in weight of the year-class is simply the difference between k and i; call this g:

$$g = k - i \tag{3}$$

If g is positive, the net weight of the year-class increases, in a year by the fraction $e^g - 1$; if g is negative, it is so written, and the year-class decreases by the fraction $1 - e^{-g}$. It was shown earlier by the writer, in a somewhat different context (1944: 29), that the average weight of an increasing year-class during a year is:

$$\frac{e^g - 1}{g} \tag{4}$$

times its initial weight; while the average weight of a decreasing year-class is:

$$\frac{1 - e^{-g}}{g} \tag{5}$$

times its initial weight.

Some other advantages of the instantaneous rates must be mentioned. First, they can be divided in strict proportion as time is divided, whereas other rates cannot. For example, if rate of growth is 100% per year, how much is it per quarter? From $b = 1.00$, $k = 0.693$, $k/4 = 0.173$; hence the quarterly increase is $e^{k/4} - 1 = 18.9\%$ of the weight achieved at the beginning of the quarter. The "quarter" under consideration is of course a quarter of the season of growth and mortality, rather than a quarter of the calendar year. Second, when two or more separate causes of mortality exist which can be independently estimated, their combined effect is found by simply adding the two instantaneous rates—a procedure which is permissible for other rates only when they are very small. Finally, the instantaneous rate of fishing mortality is directly proportional to gear in use, as long as the latter fishes in a comparable manner from year to year.

Since in work of this sort there is a constant need to change from the instantaneous to the seasonal or annual rates of mortality and growth, tables of the exponential functions e^x and e^{-x} should always be at hand. They are perhaps even more useful in the form $e^x - 1$ and $1 - e^{-x}$, and a table of the latter was included in an earlier paper of the writer's (1944: 25).

Growth rates are obtained in two general forms. The simpler is where the age of each fish is the only thing which can be determined directly, and rate of growth is inferred from the relation between age and the length or weight, in a series of fish of different ages. In this there are two dangers: first, in fast-growing fish size varies considerably within a year, so that the specimens should all be taken about the same time, to reduce the variability; second and more important, selective sampling may introduce serious error in a rather subtle manner. Near the lower limit of the size-range which it catches, any type of gear tends to select the larger individuals of the younger age-classes, so that the average size of the fish taken is not at all representative of the age-class as a whole; and similarly for the upper limit. At either end, the apparent rate of growth will be less than the true rate. This danger is perhaps not as great with intensely selective gear like gill-nets, where selection can hardly be disregarded, as with gear like trawls or hand-lines, where it is less obvious; and there are a number of growth studies in the literature into which this effect introduces considerable error.

By scale-reading, it is often possible to determine the length of each fish at a fairly definite time of year, for each year of its life. In this situation it is much easier to avoid the effect of selective sampling, since the average size at all younger ages can be computed from the size of the fish of any age-class which is randomly sampled; i.e., the gear need sample only one age-class representatively. There is a possible source of error even in this, in that differential mortality may make the average size of young fish, as calculated from older ones, less than the true average of the age-class while young (Lee's phenomenon). However, the observations from which such an effect is inferred are the same as those which are produced by selective sampling, and when the effect of the latter is eliminated it is often found that differential mortality is inconsequential (cf. Ricker, 1942: 167). Growth rates computed from scale measurements are necessarily in terms of length. To change to weight it is usually sufficient to consider that the average weight of fish of the average length is representative of the average weight of all fish in the year-class. More exactly, the latter will be a somewhat greater quantity; how much greater, depends on the variability in size of the fish in the year-class. The writer has found 1 and 2 per cent for two age-classes of bluegills; Graham (1938a) makes it 5 per cent for age II cod. Whenever it is feasible, this matter should be checked, and corrections can be made if the increase in accuracy justifies the trouble.

The average weight of the fish in a year-class, plotted against age, shows the absolute per annum mean increase in weight. To obtain the instantaneous rate of increase at any time, the logarithms of these weights are plotted against age. The slope at any point on the curve obtained is a measure of the instantaneous rate of growth at that time; it should be multiplied by 2.30 to be in the same unit as k above, if base 10 logarithms have been used. Fishes vary considerably in the nature of their growth curves: a comparative study of the numerous examples in the literature would be valuable. In general, instantaneous rate of growth decreases with age, though it may be nearly constant for two or three years while the fish is young. On an absolute scale, this means of course that the yearly increase in weight increases while the fish is young, but sooner or later it too falls off, in most if not all cases.

Estimation of mortality rate is done by two principal methods. The best known of these is the tabulation of the frequencies of occurrence of fish of successive ages in a sample presumed to be representative. If recruitment to the smallest age used is uniform from year to year, the ratio of age $n + 1$ to age n in a sample is a measure of survival rate between those ages. If recruitment is not uniform, then by using data for a period of years inequalities can be averaged out. At least two improvements on this procedure have been proposed. 1. Instead of comparing successive age-classes in a single sample, the age $n + 1$ fish this year can be compared with fish of age n last year, in samples of equal or equalized size, taken by similar gear. 2. Even better is a similar comparison made from samples which represent the yield of the same amount of fishing effort in the two years (cf. Graham, 1938a). The age-census method however is weak when recent changes have occurred, of the nature of long-term trends rather than accidental fluctuations, in the total mortality rate of the fish or in the annual recruitment to commercial sizes. Either of these phenomena might occur as a result of a more or less steady

increase, or decrease, in fishing effort over a period of time; or they might occur naturally, though probably for more limited periods as a rule.

Some of these opportunities for error are avoided when the calculation is made from a stock of marked or tagged fish, the ratio of the number of tags recovered in two successive years being considered an estimate of the survival rate. However both this method and that of the age-census are often made less reliable by the existence of differences in rate of fishing for fish of different sizes, so that the population is not randomly sampled. Consideration must be given to all these sources of error in assessing the reliability of the final result.

The marking method of estimating mortality tends to be troublesome and expensive, so it is commonly resorted to only because it can be made to provide information which the age-census method cannot: namely, the separate contributions of fishing and natural death to the total mortality rate. In a simple situation where fish can be marked immediately prior to the fishing season, the fraction recaptured by fishermen in a year (obtained either from a complete catch census or an adequate sample) gives the rate of exploitation. From this and from the total mortality rate, the instantaneous fishing mortality rate, or rate of fishing, can be computed (e.g. Ricker, 1945). When marking must be done during the fishing season, less direct methods must be employed (see Thompson and Herrington, 1930,[2] and Graham, 1938b, for extrapolation methods; also Ricker, 1945). The difference between the total instantaneous mortality rate and the rate of fishing is the instantaneous rate of natural mortality.

Another ingenious method of estimating rate of fishing has been developed by Silliman (1943), making use of a situation where two distinct and more-or-less stabilized levels of exploitation had existed in a fishery, for each of which total mortality rate a and fishing effort f could be calculated. Assuming that the instantaneous natural mortality rate q does not change, and knowing that rate of fishing p varies as f, the absolute value of p can be calculated for both levels of mortality.[3]

In this paper we are concerned with the means by which information on growth and mortality rates can be used for determination of the best size at which fish should be caught, if maximum yield is to be obtained. In other words, should minimum size limits be imposed, and if so, at what length in any particular case? Such limits of course have often been imposed only with a view to conserving an adequate breeding stock (though at times with little or no information available as to what size of stock really is adequate). The other reason for proposing size limits has been the view that the younger fish should be allowed to grow bigger before being caught, on the assumption that if a limit is adopted, a greater total catch will be secured from each brood.[4] It is in this connexion that the determination of growth and mortality rates is most valuable. By comparing the instantaneous rate of growth with the in-

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[2] A word of caution concerning Thompson and Herrington's method is in order. The figure which they obtain is an estimate of the *instantaneous* rate of fishing mortality, whereas they interpret it as the *annual* rate of fishing mortality. Also the line used in extrapolation (their figure 20) is straight, whereas theoretical considerations indicate that it should be somewhat curved (convex upward).

[3] That is, from the equations: $a = 1 - e^{-i}$; $p + q = i$; $f_2/f_1 = p_2/p_1$. The method of calculation actually used by Silliman is less direct, but gives the same result.

[4] A limit might also be proposed merely as a means of increasing the average length of the fish caught to some more desirable size, without anticipating any increase in total catch, or even at some sacrifice of total catch.

stantaneous rate of natural mortality, a size can be determined at which the two are equal; this is named the ***optimum size*** by Herrington (1944), but I prefer to call it the *critical size,* since in this connexion the term optimum has been used in the sense of the best minimum size.

The critical size as determined in this way applies to the average length of a whole year-class. Since a minimum size limit will ordinarily have to apply to the fish individually, it is necessary to make the assumption that what is true of the whole year-class is also true of the individual fish, on the average. This assumption is perhaps not above question, and it would be desirable to test it experimentally; but it seems likely to be substantially true. If so, the critical size is the size at which the fish can most efficiently be harvested, since at that time they will have reached their greatest bulk.

Ordinarily fish cannot be harvested like grain, exactly when the crop is "ripe." It is impractical to take all the fish just as they reach the critical size; which means some of them will live some months or years past it. Such older stock suffers a net loss of bulk as time goes on; hence the catch from it is less than what would be obtained by more intensive fishing. Even without more intense fishing a part of it may be saved by catching some fish at a size less than the critical size. Such small fish should be taken down to the point where the total increase of weight which the small fish caught *could have* made, if they had not been molested before they reached the critical size, is just balanced by the total loss of weight among all fish which survive beyond the critical size: i.e. this loss is the difference between the weight of a given group as it passes the critical size and the weight of all of its members which are caught. When this is true, the total loss of bulk will be a minimum, and catch a maximum.

Obviously then the critical size is not the same thing as the best *minimum* size at which fish should be caught, if maximum yield is desired. The desirable minimum size will depend partly on this critical size, and partly also on the rate of fishing. If a population is very lightly fished, maximum yield will be obtained by keeping all fish caught, regardless of size. As fishing effort increases a limit of size should be imposed to ensure maximum yield, which limit should approach the critical size, as fishing effort increases indefinitely. The maximum yield in question is that which would be obtained from whatever recruits are available. Extreme changes in rate of fishing, however, may have a secondary effect on the number of recruits, and this in turn may affect their rate of growth. Consequently a determination of best minimum size will apply first and foremost to the conditions actually prevailing. Following such a determination, minima corresponding to *moderate* departures from the observed rate of fishing can also be worked out, and will probably have some value.

Example.—The writer (1945) has published determinations of natural mortality rate and rate of growth for some of the fishes in two Indiana lakes. The species involved can be divided rather arbitrarily into two groups. There are those in which several age-classes appear in the catch, and mortality rate does not greatly differ from one to the other except probably for the very largest individuals. On the other hand there are species in which the natural mortality rate obviously increases rapidly throughout the range of catchable ages. An example of the first type is the bluegill (*Lepomis macrochirus*), an

abundant and popular game fish. In Table I is shown the computation of the critical size and optimum minimum size for the bluegills of Muskellunge Lake. Since the rate of growth and mortality change rapidly in places, the computation is made by quarter-years, each age shown being at the middle of its quarter. The mean length at successive ages, to the fork of the tail, is shown in column 2, and the mean weight corresponding to that length is in column 3.

Table I

Instantaneous Rates of Growth (k), Natural Mortality (q) and Fishing Mortality (p), at Quarter-Year Intervals, for Bluegills of Muskellunge Lake, Indiana, and the Computation of Relative Yield. See the Text for a Detailed Description.

1	2	3	4	5	6	7	8	9	10	11	12	13	14
Mean age	Mean length mm.	Mean wt. grams	k	q	$k-q$	p	$g = k-(p+q)$	$g/4$	$e^{g/4}-1$ or $1-e^{-g/4}$	Change in weight	Weight of pop'n.	Average weight	Catch
											100		
II	95	13	2.2	(0.6)	+1.6	0	+1.6	+0.400	+0.492	+49		123	0
											149		
II¼	109	29	2.0	(0.6)	+1.4	0	+1.4	+0.350	+0.419	+62		178	0
											211		
II½	122	44	1.8	0.6	+1.2	0.5	+0.7	+0.175	+0.191	+40		230	28.7
											251		
II¾	135	58	1.4	0.6	+0.8	0.5	+0.3	+0.075	+0.078	+20		261	32.6
											271		
III	145	69	0.8	0.6	+0.2	0.5	−0.3	−0.075	−0.073	−20		261	32.6
											251		
III¼	153	80	0.5	0.6	−0.1	0.5	−0.6	−0.150	−0.139	−35		233	29.1
											216		
III½	160	91	0.4	0.6	−0.2	0.5	−0.7	−0.175	−0.160	−35		198	24.8
											181		
III¾	165	101	0.4	0.6	−0.2	0.5	−0.7	−0.175	−0.160	−29		166	20.8
											152		
IV	170	110	0.3	0.6	−0.3	0.5	−0.8	−0.200	−0.181	−28		138	17.3
											124		
IV¼	175	118	0.2	0.6	−0.4	0.5	−0.9	−0.225	−0.202	−25		111	13.9
											99		
IV½	178	125	0.2	0.6	−0.4	0.5	−0.9	−0.225	−0.202	−20		89	11.1
											79		
IV¾	182	131	0.2	0.6	−0.4	0.5	−0.9	−0.225	−0.202	−16		71	8.9
											63		
V	185	137	0.2	0.6	−0.5	0.5	−1.0	−0.250	−0.221	−14		56	7.0
											49		
V¼	188	143	0.2	(0.7)	−0.5	0.5	−1.0	−0.250	−0.221	−11		43	5.4
											38		
V½	191	148	0.1	(0.8)	−0.7	0.5	−1.2	−0.300	−0.259	−10		33	4.1
											28		
V¾	193	153	0.1	(1.0)	−0.9	0.5	−1.4	−0.350	−0.295	− 8		24	3.0
											20		
VI	195	158	0.1	(1.3)	−1.2	0.5	−1.7	−0.425	−0.346	− 7		16	2.0
											13		
Total													241

Column 4 is the instantaneous rate of growth k, determined by using freehand tangents on a graph of the logarithm of weight against age, as described earlier. In the next column is the instantaneous rate of natural mortality, determined from a marking experiment over the legal size range. There is no direct information on its magnitude at sizes less than 122 mm., but on another lake bluegills from 105 to 122 mm. were shown to have a natural mortality rate very close to that of the larger ones. Similarly the increase in q suggested beyond 185 mm. is based on conditions elsewhere, though the actual values quoted are largely guesswork; however such fish are few in number

and contribute little to the total catch. Fish older than age VI are very scarce and have been omitted. The difference between k and q, shown in column 6, represents the tendency of the population to increase or decrease, if fishing were suddenly to cease. The rate of fishing $p = 0.5$ in column 7 is an estimate of the rate which prevailed prior to the present war; it corresponds to an annual fishing mortality rate of $m = 39$ per cent (i.e. if there were no natural mortality). Fish smaller than the II½ group are not caught, hence for them $p = 0$. The net annual instantaneous increase or decrease in weight g is shown in column 8. Since the computation is made by quarters, this is divided by 4 in column 9 to give the instantaneous rate of change on a quarterly basis. The corresponding actual increase or decrease per quarter, in column 10, is found from an exponential table. In column 12, a group of fish is shown which weighed 100 units just prior to the first quarter, and its increase and decrease in bulk is followed throughout the whole course of its existence. Column 11 is used in computing 12, it being the product of the change in weight during any quarter (10) and the weight at the start of the quarter (12); it is added or subtracted, as the case may be.[5] The average weight of the population in any quarter (13) is found from its weight at the beginning and end of the quarter. Usually a simple average is close enough, but since the increase (or decrease) is exponential, it is more accurate to use expressions (4) and (5) above, substituting $g/4$ for g. For this purpose $g/4$ and the corresponding $1 - e^{g/4}$ should be taken to 3 figures. Finally, the catch in each quarter is estimated in column 14 as the product of the quarterly rate of fishing (¼ of column 7) and the average population (13). The sum of column 14 gives the total catch under the given conditions of growth, natural mortality and rate of fishing.

The figures of Table I can now be varied in order to ascertain, first of all, what minimum size limit will result in the maximum catch. In doing this it is not necessary to repeat the whole of the computation. If, for example, we are examining the effect of a limit which exposes all fish of the II¼ group and older to the full rate of fishing, then a change in the row for II¼ must be made, which will result in the number of fish surviving that age being less than the 211 weight-units shown in Table I; let us say their weight is x. From that point onward these fish are subject to the same conditions as before, so in order to obtain, under the new conditions, the total catch from fish of age II½ and greater, it is necessary only to total their contribution under the conditions of Table I, and multiply it by $x/211$. The contribution of age II¼ is computed separately, and added to this to obtain the total catch under the new conditions.

Another possible variation that can be made is in the rate of fishing—to see what will be the desirable size if fishing increases or decreases. In addition to $p = 50$ per cent, we have used $p = 30$ per cent, which is close to the present (1942) rate of fishing, and also the rather large value of $p = 100$ per cent. This last figure constitutes a rather extreme extrapolation from the observed data, but is included here for purposes of illustration. The catches, for these three different rates of fishing and for six different minimum sizes, are as follows:

[5] An alternative procedure would be to tabulate $e^{g/4}$ or $e^{-g/4}$ in column 10, and find the figures in column 12 by direct multiplication, omitting column 11. However, column 10 as given is useful in estimating column 13.

	Rate of fishing (p) 0.3	0.5	1.0
(1) Minimum size 102 mm., so that all fish of age II¼ and larger are vulnerable:	186	233	268
(2) Minimum size 116 mm., so that all fish of age II½ and larger are vulnerable:	187	241	293
(3) Minimum size 122 mm. (the present legal minimum), so that fish of age II¾ and larger are vulnerable, and also a part of the fish of age II½ (found by interpolation):	185	243	303
(4) Minimum size 128 mm., so that all fish of age II¾ and larger are vulnerable:	183	241	312
(5) Minimum size 140 mm., so that all fish of age III and larger are vulnerable:	173	231	305
(6) Minimum size 149 mm., (the critical size), so that all fish of age III¼ and larger are vulnerable:	158	214	290

The above figures show the number of pounds of fish which will be caught, for every 100 pounds of fish which reach 88 mm. (3½ inches) in length, or nearly II years of age (really I-⅞ years). The optimum minimum size is about 108 mm. for $p = 0.3$, it is 122 mm. for $p = 0.5$, and for $p = 1.0$ it would be about 132 mm., if there were no serious change in rate of growth. That is, under pre-war conditions of exploitation the current legal minimum was in fact the best one. In another lake for which a similar determination has been made, the best minimum was much smaller—in fact the critical size was a little less than the legal minimum; but of the two, Muskellunge Lake is much more typical in respect to rate of growth.

However, what is most interesting in the schedule above is the fact that there is a rather broad zone of minimum lengths over which little change in catch occurs. For example, with minima anywhere from 102 to 140 mm., for $p = 0.5$, yield is never less than 96 per cent of the maximum. Even with $p = 1.0$, for which the maximum yield is say 315 units, any limit from 116 to 149 mm. would yield not less than 92 per cent of the maximum. This situation has a number of implications: for one thing, there is considerable leeway allowed for errors in the data from which the computation of minimum length is made; second, it is evidently not an important matter, in this particular example, to determine the *exact* optimum minimum size for maximum catch; third, if it could be shown that a certain minimum is best from the point of view of regulating the number of spawning fish so as to obtain optimum recruitment, then a very considerable adjustment of the minimum can be made to meet this requirement without sacrificing any significant part of the yield from the recruits at hand; and finally, if it is desirable to have a uniform minimum standard apply to a number of bodies of water for which the optimum minima are different, this will be possible without any great sacrifice of catch, provided the optima are not *too* diverse.

These conclusions seem likely to apply, in a general way, to many other fisheries. However this does not mean that little benefit is to be derived from a determination of best minimum size. In the example above we have not explored the range of possible minimum sizes below 100 mm., simply because bluegills of that size are of no interest to fishermen. Some indeed consider the current 5-inch limit too small, from that point of view. But in a fishery where the range of desirable sizes extends well down into the region where rate of growth greatly exceeds the natural mortality rate, a determination of the best

minimum may indicate that a considerable range of usable sizes of fish cannot be molested without seriously reducing the total catch. Among the game fishes of Indiana, this is probably true of the largemouth bass, and it seems likely to be true for many commercially-exploited species of the sea and of the Great Lakes. In large-scale fisheries very considerable increases in catch might result from the regulation of net sizes, etc., to conform to the desirable minimum as closely as possible.

Even where a determination of rate of fishing is not directly available, but rate of growth and total mortality rate are known, it may very often prove valuable to calculate the critical size and the best minimum size, for various estimated values of p and q. By this means, for example, a considerable range of possible minimum sizes might be excluded, as being inconsistent with any reasonable estimate of fishing and natural mortality.

It must be emphasized that the determination and use of the best minimum size for maximum yield is only one half of the biological phase of the general problem of fishery regulation. The other and harder half is the determination of the number of spawners needed for optimum recruitment. It may frequently prove desirable to make the legal minimum greater, or less, than the optimum one based on critical size, in order to permit sufficient survival of mature fish for adequate reproduction, or to prevent over-crowding of the body of water by excessively numerous broods.[6] The method outlined above shows how best use can be made of the young stock currently available. It does not show what effect a change in number of spawners would have upon the abundance of young stock, or how a change in the latter would affect the rate of growth of the species. Statistics of relative abundance (catch per unit gear) and age- and size-composition of the catch, over a period of years, may sometimes provide considerable information on these points, in fish populations whose abundance has fluctuated considerably. On small lakes, comparing yields and other pertinent data, from lake to lake, may offer possibilities. Other sources of variation, however, tend to obscure the influence of population numbers, and the intelligent regulation of recruitment will probably long remain one of the most difficult problems of fishery management.

Summary

1. The "critical size" for a year-class of fish is defined as the size at which the average instantaneous rate of natural mortality begins to exceed the average instantaneous rate of increase in weight.

2. Assuming that what is true of the year-class as a whole is also true, on the average, of the fish individually, the critical size can be used as a basis for estimating the best minimum size at which fish should be taken, in order to achieve maximum production at the existing rate of fishing.

3. The best minimum size varies with the rate of fishing, being zero when the latter is very small, and approaching the critical size when fishing is very intensive.

4. Possible secondary effects of a change in fishing intensity, on the rate of growth of the fish, make it unwise to extrapolate too far from existing conditions: i.e. the critical size may change. However such extrapolation is a

6 There may also be other considerations. For example, a species which, usable in itself, also serves as food for other more valuable species, might be best maintained at a level of abundance greater than that which would provide the maximum direct yield.

useful guide to the minimum size which will probably be desirable, following a *moderate* change in rate of fishing.

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The Pacific Coast Blackcod, *Anoplopoma fimbria*

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THE blackcod or sablefish, *Anoplopoma fimbria,* has long been the object of a fishery from northern California to Cape Spencer, Alaska, and the present wartime need for food fish has brought forth the belief that the blackcod stocks as well as those of many of our other food fish are underutilized. However, for several years, some fishermen and dealers have expressed concern over the declining abundance of the species. Apparently there is great lack of accurate knowledge regarding the blackcod as with many of our important food fishes.

That immediate attention be given to a practical assessment of the Pacific Coast blackcod fishery is indicated by the following recent developments. The valuable liver and visceral oils of the blackcod have sharply increased the intensity of fishing by increasing its profitableness. The wartime growth of the trawl fishery is placing an additional drain upon the adults and young of the species. The capture of small blackcod by trawl gear, not sought after, nor even generally capable of being caught by line gear, is a new and serious

problem. The continued shortening of the halibut fishing season coupled with the increased longline fleet also has added to the potential blackcod fishing intensity. Finally, the species is more important than ever in providing a fishing season of profitable length for boats of the longline fishing fleets of both Canada and the United States.

This paper is a preliminary statement of some of the facts known about the species and its fishery. Unless otherwise noted, most of the statistical material has been from the files of the International Fisheries Commission which had collected the same in connection with its studies of the capture of halibut by vessels engaged in other fisheries. Access to these data was granted by the Director of Investigations, H. A. Dunlop. Consideration of the southeastern Alaska fishery will not be undertaken as the above Commission turned over its Alaska data to the U. S. Fish and Wildlife Service, which has recently commenced such a survey.

Conclusions herein are those of the authors who have developed the material independently of their staff duties and time of the above Commission.

Geographical Distribution of Blackcod

The distribution of blackcod may be considered both from the standpoint of its casual occurrence in a region and its presence in commercial abundance.

The recorded range of its occurrence is from Catalina Island, California, to Unalaska, Alaska (Jordan and Evermann, 1898). It was noted as occurring in the harbor of Petropavlovsk, Kamchatka, in the MSS notes of the late Captain A. Freeman, the Pacific Coast's most well-known pioneer of deep sea fishing. However, Soldatov and Lindberg (1930) and other northwestern Pacific checklists did not record it as occurring in Pacific Asiatic waters.

The presence on the coast of blackcod in sufficient quantity to maintain an independent or mixed commercial fishery is best shown by the following table of landings in pounds (dressed weight) by sections of the Pacific Coast for 1942. These totals include the landings of blackcod of all sizes by the rapidly growing trawl fleets. In this preliminary report, it is not possible to assign the Pacific Coast landings to the precise area of capture except for the Cape Flattery region.

California	1,374,000	British Columbia	1,803,000
Oregon	622,000	Southeastern Alaska	5,680,000
Washington	2,449,000		

The California landings are secured chiefly from waters off the northern part of the state. The amount landed in Oregon is caught chiefly between Newport, Oregon, and Grays Harbor, Washington. The 1942 Washington landings originated from grounds between Destruction Island and Barclay Sound on Vancouver Island.

Catches landed by Canadian vessels in British Columbia are largely derived from waters off the west coast of Vancouver Island, in Queen Charlotte Sound, and with a considerable portion coming from the extraterritorial waters of the southern part of the archipelago of southeastern Alaska.

The landings of the United States fleets in southeastern Alaska are derived from the waters of Chatham and Icy Straits, Frederick Sound, and in the offshore waters between Cape Spencer and Cape Ommaney. Beyond

Cape Spencer, blackcod are found in moderate quantities as far west as the Shumagin Islands but apparently not in the concentrated abundance noted in Chatham Straits and in the Cape Ommaney and Cape Flattery regions.

It is believed that the wide ranging line fishery for halibut and the observed decline of the known blackcod stocks would have long ago brought into production other areas had they possessed significant and profitable stocks of blackcod. Good short time yields from newly found local concentrations on both new and old grounds may be expected but it is certain that this will not compensate for the lowered yields from the already exploited stocks.

History of the Fishery

Prior to 1916 large amounts of blackcod were brought in only with prior agreement of buyers, as abundant supplies of salmon and halibut, up to that time, satisfied the market demand. However, a limited trade in fresh and salt blackcod had been conducted for many years. Swan (1885) reports seeing blackcod utilized by the Indians at Neah Bay in 1859 and states that in 1884 several Victoria, B.C., boats outfitted for blackcod salting off the Queens Charlotte Islands. Captain Dave Barry of Vancouver, B.C., states that commercial salting was carried out in 1890-91 on the west coast of Queen Charlotte Islands and from about 1908 to 1911 a shore saltery was operating at Millbank Sound. Samson (1940) described a short-lived salt blackcod fishery carried on by Seattle boats in southeastern Alaska in the winter of 1939-1940 due to a short supply of salted chum (*O. keta*) salmon that year.

Table I

Pacific Coast Blackcod Catch According to Region of Landing
(In Thousands of Pounds i.e. 000 omitted)
Dressed Weights

Year	California and Oregon U. S.	Washington U. S.	British Columbia U. S.	British Columbia Can.	Alaska U. S.	Total U. S. & Can.
1915	61	576	3587**		143	4367
1916	52	2039	6337**		304	8723
1917	828	2430	345	8408	1020	13031
1918	599	4355	403	2594	1336	9287
1919–22*	560	1259	254	1887	384	4344
1923–26*	694	2140	238	1267	701	5040
1927–30*	1061	2397	234	1307	652	5651
1931–34*	1020	1649	44	585	161	3459
1935–38*	1032	2799	340	969	1087	6227
1939	634	3067	432	907	1626	6666
1940	468	2438	640	1393	1959	6898
1941	516	2295	762	1747	2847	8167
1942	1996	2449	575	1228	5680	11928
1943	2500***	2309	178	2096	4084	11167

* Annual Average
** Total U. S. and Canadian
*** Includes estimate of California catch

In 1914 and 1915 the United States Bureau of Fisheries survey vessel "Albatross" reported (Schmitt, Johnston, Rankin and Driscoll, 1915; Johnston, 1917) a reasonable abundance of blackcod on Heceta Bank, Oregon Coast, and off the Washington Coast from Grays Harbor to Cape Flattery, but no immediate sustained fishery developed. The first World War food de-

mand resulted in Pacific Coast blackcod landings sharply rising by 1917 to 13,031,000 pounds from 4,367,000 in 1915. The U. S. Bureau of Fisheries at that time publicized the name 'sablefish' to stimulate the consumer demand. In spite of this, 'blackcod' is still the most commonly used popular name for the species.

The development of the fishery is further reflected by the landings as shown in Table I, according to various published and unpublished sources including the Pacific Fisherman, the reports of the U. S. Bureau of Fisheries and its successor, the U. S. Fish and Wildlife Service, the California Division of Fish and Game and the Fishery Statistics of Canada and files of the International Fisheries Commission.

The catches are presented as four-year averages to conserve space, with the exception of the years 1915–1918 and 1939–1943, which include the two wartime periods of expansion.

The Present Blackcod Fishery

The Cape Flattery fleet is normally represented by about 40 boats which after the cessation of halibut fishing engage in blackcod fishing. In northern California and Oregon about one-half dozen boats may also be so classified. The British Columbia fleet has approximately 50 vessels and that of southeastern Alaska about 70 vessels. About 850 men are represented in the crews of the above 166 boats.

The present season of the Cape Flattery fishery is indicated by the fact that 84 per cent of the Seattle blackcod landings are made in the months of August, September, October, and November. In British Columbia it is likewise a fall fishery. In southeastern Alaska, the availability appears to extend from March to at least November. Since market conditions and the relative attractiveness of other fisheries influence the amount of fishing for blackcod no final statements may be made as to the general seasonal availability of the species on different sections of the coast. It is known, however, that during the late winter and early spring months in the Cape Flattery region blackcod are not available.

Trawl Capture of Blackcod

Of recent development has been the capture of blackcod by the expanding fleet of trawlers. In California in 1941, 1 per cent of the 6,178,838 pounds of the state total trawl caught fish, or 51,530 pounds, consisted of blackcod. Of this, 36,900 pounds were caught on grounds immediately off Mendocino City in which area blackcod represented 21 per cent of the trawl caught fish (Cal. Division of Fish and Game, MSS data).

In Oregon, blackcod are caught in some quantity by otter trawlers. An estimate based on incomplete figures of 1944 landings indicates that 1 per cent of their poundage consisted of blackcod totalling about 100,000 pounds.

In Washington about 660,000 pounds of blackcod were landed in 1943 by the trawl fleet which represents about 5 per cent of their landings of food fish. In the months of September and October, when blackcod were a more significant factor in the trawl catches, the percentages of blackcod to other food fish were 15 per cent and 14 per cent respectively.

Limited amounts of blackcod are landed by the Canadian trawl fleet but it is estimated not to exceed 20,000 pounds. In the course of trawling with

the present mesh of gear quantities of small blackcod from $1\frac{1}{2}$ to 2 pounds dressed weight are caught and, unfortunately, at least 95 per cent of them cannot be returned to the sea alive. The acute wartime demand for food fish in 1943 resulted in over 250,000 pounds of these small fish being marketed in Washington. Normally they are unmarketable.

On the basis of observations on the grounds, testimony of fishermen, and actual records of landings, it is estimated that the Washington and Oregon trawl fleets killed about 1,500,000 pounds of such small blackcod in 1943, of which less than 20 per cent were utilized. By number, this 1,500,000 pounds is about 5 times that of all the adult blackcod landed by the Seattle line fishery in 1943 and about equal to the number of blackcod represented in the 1943 Pacific Coast line-caught total catch of 11,167,000 pounds.

Size and Age

Blackcod are known to attain a large size. The "Albatross" (Johnston, 1917) reports the capture of specimens of 40 to 50 pounds off Umatilla Lightship in 1915. The captain of the halibut vessel "Forward" reports weighing out a specimen of 126 pounds, head on and entrails removed, caught off southeastern Alaska in 1916.

Very large schools of small blackcod about 10 inches long were observed on August 7, 1934, by Dr. John L. Hart of the Pacific Biological Station, Nanaimo, B.C., about the waste outlet of a fishmeal plant at Nootka, B.C., on the west coast of Vancouver Island. They remained in that vicinity for several weeks.

No age determinations of the blackcod have been published. Examination of the scales of some small fish 40 to 70 cm. in length show them to be from 2 to 4 years of age. The undersized specimens of $1\frac{1}{2}$ to 2 pounds caught by the otter trawl fishery appear to be mostly 2 or 3 years of age.

Spawning Season

No determinations regarding the spawning season are published but interviews with 15 captains of long experience with Cape Flattery blackcod fishing revealed that the ovaries of the blackcod in that region showed signs of enlargement and that the ova increased in size and fluidity in late October and early November. Only two of the 15 men had seen the ova in a ripe or "watery" condition. Spawning appears to take place shortly thereafter as all of the few blackcod caught early in the year in the Cape Flattery region are in a "spent" state.

A blackcod with ripe and running eggs was caught in 137 fathoms off Cape St. James at the south end of Queen Charlotte Islands on March 4 (Thompson, 1941). The eggs were described as free floating eggs of the pelagic type with a mean diameter of 2.06 mm. Comparison with eggs taken in net hauls during the season suggest that spawning started about February 1 in that region.

In May, 1939, four post larval blackcod were taken at the surface 100 to 180 miles off Cascade Head, Oregon (Brock, 1940). They ranged from 21–35 mm. in length and had the adult appearance except the pectorals were proportionately longer than in the adult.

Processing and Marketing

Most of the Pacific Coast blackcod catch is smoked with a limited amount marketed in the fresh state, particularly in California (Walford, 1931). When landed, the catches are usually frozen to permit their storage or their shipment to other than the landing port. The product is sold as smoked or barbecued blackcod.

The fat content of the fish is very high and the muscle has 7200 USP Vitamin A units per pound (Bailey, 1944). The smoked product is in demand by the restaurant and Jewish trade.

There has been at times a good market for salt blackcod when the cheaper species of salt salmon were in a short supply. The fast disappearing first generation of Scandinavian people of the Northwest and Middle Western States once provided a good demand for the salt product. Only with abundant stocks can the fish be caught at costs that keep the prices of the salted products attractive to such trade as the native plantation labor of the Hawaiian Islands where once there was a good salt cod market.

The Cape Flattery blackcod are preferred to those from Alaska on account of their larger average size, increased firmness, and that they dress out 6 to 10 per cent more smoked fish. Since the available stocks of blackcod are not and never have been large, the annual production can always be readily marketed. Only occasionally has there been any coldstorage carryover and those were the smaller sizes only.

Livers and Viscera

Blackcod livers were first bought commercially in the United States in 1932 at 12 cents per pound, the price increasing to 15 cents in 1933 and rising steadily to reach the pool price of $1.70 in 1943. The intestines, known as the viscera, were first utilized in 1937 and by 1939 were being widely retained. They increased in price from 8 cents per pound in 1939 to the pool price of 42 cents in 1943.

The financial returns from the liver in recent years represent 30 per cent of the total earnings of the Cape Flattery blackcod boats, having increased from 17 per cent in 1933 when livers were at their early low price. The inclusion of the value of the viscera in recent years has accounted for an additional 9 per cent of the financial returns from the fishery.

The seasonal percentage of livers to weight of dressed fish is shown in the following table based on records of many individual fares.

	May	June	July	Aug.	Sept.	Oct.	Nov.	Ave.
Cape Flattery Area (1939)	2.32	3.01	3.28	3.64	4.02	4.20	4.74	4.01
Southeastern Alaska * (1941)	2.90	2.84	3.15	3.15	3.35	3.43		3.25

* Chiefly Chatham Straits.

The proportion increases from the beginning to the end of the season and is higher in the Cape Flattery region than in southeastern Alaska. Analysis of 62 blackcod livers from northern Hecate Straits in September and October, 1938, showed liver to be 3.14 per cent (corrected to dressed weight) of the dressed weight (Pugsley, 1940), which places them in the southeastern Alaska group.

The viscera retained represent about 4 per cent of the weight of the dressed heads-off weight of Cape Flattery fish and a somewhat higher per-

centage in southeastern Alaska. Hecate Strait fish (Pugsley, 1940) had a figure of 3.9 per cent when corrected to the dressed heads-off basis.

The Vitamin A potency of the livers, viscera, and their extracted oils vary according to locality, season, and size of fish. The importance of the species as a source of Vitamin A can be judged by the fact that about 300,000,000 International Units of Vitamin A are available from the livers and viscera of each 1,000 pounds of the landed catch.

Condition of Stocks

The major question in the management of any stock of fish is whether the species is providing the maximum annual yields that it is capable of doing in perpetuity. In an uncontrolled fishery, the stocks are usually maintained on abundance levels at which the fleets can afford to fish and not necessarily at those levels that assure maximum yields. Such mismanagement or overfishing eventually results in underutilization of the marine environment. The resultant lowered production is sold at the highest possible prices to the consumer with the lowest possible returns to the fishermen.

Due to the preliminary nature of this report and the complexity of factors involved it is impossible to determine the extent to which overfishing may have taken place. Changes in the extent of the grounds fished, decline in average size and in the catch per unit of effort and the relationship between the amount of fishing and yield suggest that some degree of overfishing has already taken place.

Extent of the Cape Flattery Fishing Grounds

The distribution of the fishery in this region since 1916 has undergone some changes. In that year fishing was conducted between Cape Flattery and Cape Beale, extending in 1917 further south to Destruction Id., the latter grounds having been discovered in the preceeding year. With the decline in abundance on these areas the Heceta Bank grounds off Oregon were opened up. These southern areas have not been the consistent producers that those of the Cape Flattery region have been. The Oregon banks are outside the Cape Flattery region and their production is not included in this analysis.

Certain sections within Cape Flattery region have been very productive from time to time. In 1922 the grounds off Carmanah Point, Vancouver Id., were explored and from 1924 to 1940 they produced a considerable proportion of the total catch after which severe decline set in. In later years, particularly since 1940, the fishery has become largely dependent upon the production from more restricted 'spots' in the region. In 1943 one such 'spot' near Swiftsure Lightship was the mainstay of the fishery.

Decline in Average Size

Since the average size of blackcod in this region appears to vary from one section of the grounds to another, and possibly seasonally, further studies are required before definite conclusions can be reached as to the changes in average size caught. The present data show a decline in the average size of line-caught blackcod in the Cape Flattery region as a whole in recent years. Statements of men who fished on these grounds when they were first exploited in 1917 and 1918 indicate that the fish averaged 15 to 17 pounds by weight. In subsequent years up to 1940 an average weight of 12-13 pounds

appears to have been maintained. Since 1940, some evidence indicates a further decline to a 10-11 pound average. The failure of the Carmanah Point ground which, between 1924 and 1940, contributed excellent fish of large size and good quality may have contributed to this recent decline in the average size of the landings as a whole.

In southeastern Alaska, for which more complete data are available, a well-defined reduction in average size has been noted.

Catch per Unit of Effort

Table II shows the catch per unit of effort, the total catch, and the calculated number of skates fished on the grounds in the Cape Flattery region between Destruction Island and Barclay Sound, about 75 miles apart, for the months of August to October inclusive. This covers the major portion of the Cape Flattery fishery both as to season and area.

Table II

Cape Flattery Region

Landings in 1000 Pounds, Catch Per Skate in Pounds and No. of Skates Fished.

Year	Landings	Catch per Skate	Cal. No. of Skate Fished
1917–18*	3392	250.0	13,568
1919	1554	205.6	7,558
1920	950	180.6	5,260
1921	1519	157.5	9,644
1922	1010	129.4	7,805
1923	2104	113.0	18,619
1924	1964	108.5	18,101
1925	1710	111.4	15,350
1926	1458	108.3	13,463
1927	1486	99.2	14,980
1928	1389	95.4	14,560
1929	1968	88.8	22,162
1930	2450	79.3	30,895
1931	1149	76.4	15,039
1932	1464	73.6	19,891
1933	1080	70.8	15,254
1934	1759	68.0	25,868
1935	2112	64.9	32,542
1936	1988	58.4	34,041
1937	2229	56.3	39,591
1938	2284	59.9	38,130
1939	2251	53.6	42,233
1940	2041	53.7	38,007
1941	1687	59.4	28,401
1942	1896	73.8	25,691
1943	1430	63.2	22,626

* Average of two years.

The catch per unit of effort has declined from approximately 250 pounds per standard 6 line skate of long line gear at the time of the first heavy fishing in 1917–1918 to 54 pounds in 1939–1940. A temporary improvement in 1941 and 1942 was not sustained, as preliminary figures for 1944 show a catch per skate below 60 pounds. Due to the present 'spot' nature of the fishery and the possible effects of trawling on the grounds and natural fluctuations of the stock, short time changes in the catch per unit of effort should not be given undue weight.

The general trend of the decline averaged 7 per cent per year from 1917–1940 which is not unlike the continuous decline of 8 per cent annually from

1906–1928 noted in the abundance of halibut between Cape Scott and Dixon Entrance (Thompson, Dunlop, and Bell, 1931). This correspondence between the history of abundance in the two fisheries suggests that the degree to which they had been overfished may be the same. It has been demonstrated that the halibut stocks were in a deplorable condition by 1928 to 1930 and that subsequent international regulation of the halibut fishery has resulted in more than doubling of the abundance as well as increased annual yields.

Relationship Between Intensity of Fishing and Yield

Since the inception of the fishery a generally upward trend in the amount of gear fished occurred which had maintained the production in face of the

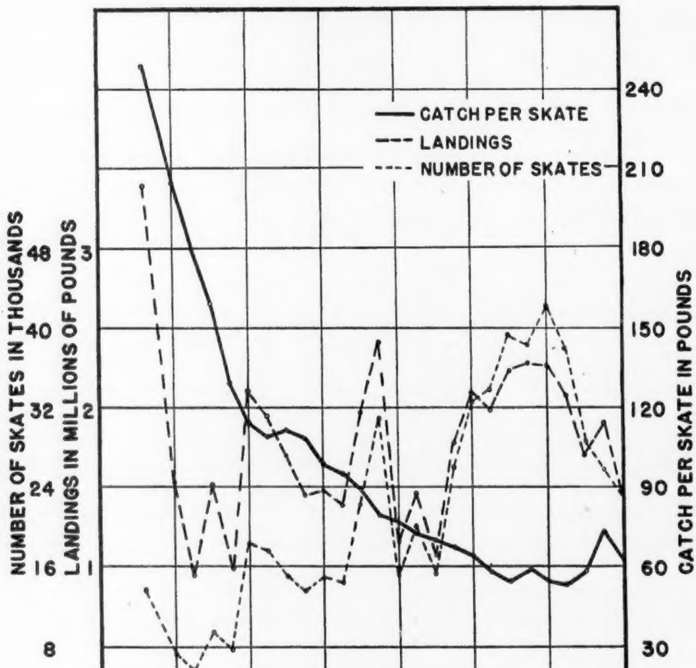

Fig. 1. Total landings, catch per skate, and calculated number of skates fished in the Cape Flattery area from 1917 to 1943.

declining abundance as shown in Figure 1. Over shorter periods, such as from 1923 to 1933, though the intensity of fishing was generally constant the production tended to decline. For the period between 1936 and 1939 when

the intensity was increased, a proportionate increase in production did not take place. Thus, over the whole history of the fishery and within shorter periods there are indications that the amount of gear fished has been in excess of what the stock could stand and that maximum yields from those stocks have not been attained.

Conclusions

The blackcod fishery is a valuable resource with an established market for its products. It is evident that a practical coastwise investigation should be instituted in order to ascertain the type of corrective measures required to put the blackcod fishery on a secure and permanently productive basis. To do otherwise and permit such fisheries to exist at low and costly levels of productiveness is economically unsound.

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A New Cyprinid Fish from Southern Arizona, and Sonora, Mexico, with the Description of a New Subgenus of *Gila* and a Review of Related Species [1]

By Robert R. Miller

THE cyprinid fishes of western North America that have been assigned to the genera *Gila, Siboma, Tigoma, Cheonda,* and *Richardsonius* are in need of revision. Scale structure and the shape of the pharyngeal bones deserve particular attention. Only two of these nominal genera, *Richardsonius* and *Gila,* are given full generic rank in this paper. I have examined the type and only known specimen of *Cheonda cooperi* Girard (USNM No. 238), genotype of *Cheonda* Girard, and agree with Schultz and Schaefer (1936: 8–10) that it is probably an intergeneric hybrid between *Mylocheilus* Agassiz and *Richardsonius.*

Genus *Richardsonius* Girard

Richardsonius.—Girard, Proc. Acad. Nat. Sci. Phila., 8, 1856: 201. Genotype, *Cyprinus (Abramis) balteatus* Richardson.

Richardsonius, as currently restricted to *R. balteatus* (Richardson) and *R. egregius* (Girard), is regarded as a valid genus. An examination of the type of *Tigoma humboldti* (USNM No. 225) shows it to be a synonym of *Richardsonius balteatus.* The fish obviously was not collected in Humboldt River, Nevada, for this stream, a part of the Lahontan basin, is inhabited by *Richardsonius egregius* (Snyder, 1917: 54–57).

Genus *Gila* Baird and Girard

Gila.—Baird and Girard, Proc. Acad. Nat. Sci. Phila., 6, 1853: 368. Genotype, *Gila robusta* Baird and Girard.

Following is a list of the species currently referred to *Gila,* with probable subgeneric divisions. A similar arrangement was made by Jordan and Evermann (1896: 229–242) and later Jordan (1924: 70) further clarified the systematic position of the American cyprinids referable to the Leuciscinae, but the limits of the genera or subgenera have not been defined previously. Undoubtedly both the list of species and the divisional arrangements of subgenera are somewhat tentative and will undergo modification as new material comes to hand and further investigations are made.

One new subgenus is proposed herein.

Subgenus *Gila* Baird and Girard

Scales small, without basal shield, generally more than 65 in lateral line, with apical and lateral radii and, rarely, basal radii; teeth 2,5-4,2; dorsal origin behind insertion of pelvics.

Gila robusta Baird and Girard.—Abundant in the drainage of the Colorado River system in Arizona, New Mexico, Utah, Colorado, and Wyoming, and in the remnant waters of the White River in eastern Nevada.

Gila elegans Baird and Girard.—At one time common in swift channels of the Colorado and Gila rivers and larger tributaries in California, Arizona,

[1] Published by permission of the Secretary of the Smithsonian Institution.

Nevada, New Mexico, Utah, Colorado, and Wyoming. Probably this is an ecological subspecies of *Gila robusta*.

Gila minacae Meek.—Yaqui River of Chihuahua and Sonora, Mexico. Probably from other streams of the Pacific slope in northwestern Mexico.

Gila nigrescens [2] (Girard).—Basin of the Río Grande in Colorado, New Mexico, Texas, and northern Mexico.

Subgenus *Siboma* Girard

Siboma.—Girard, Proc. Acad. Nat. Sci. Phila., 8, 1856: 209. Genotype, *Siboma crassicauda* Girard.

Scales large, without basal shield, generally less than 65 in lateral line, with apical radii only; teeth, 2,5-4,2; dorsal origin over insertion of pelvics.

Gila crassicauda (Baird and Girard).—Formerly abundant in the lower Sacramento and San Joaquin rivers and in the lower courses of the larger tributaries of San Francisco Bay. Also present in Clear Lake, about 90 miles north of San Francisco, a disrupted portion of the Sacramento River system. I have examined the type of *Lavinia conformis* (USNM No. 231) and find it to be a large-scaled variant of *Gila crassicauda*.

Gila atraria (Girard).—Widespread in the basin of Pleistocene Lake Bonneville and in the Upper Snake River, in eastern Nevada, Utah, Idaho, and Wyoming.[3]

Gila parovana (Cope).—Known only from Beaver River, Utah. Probably only a subspecies of *G. atraria*.

Subgenus *Temeculina* Cockerell

Temeculina.—Cockerell, Proc. Biol. Soc. Wash., 22, 1909: 216. Genotype, *Phoxinus* (*Tigoma*) *orcuttii* Eigenmann and Eigenmann.

Scales moderate to rather small, rounded at base, 45-75 in lateral line, with strong radii on all fields; teeth 2,5-4,2; dorsal origin behind insertion of pelvics.

Gila orcuttii (Eigenmann and Eigenmann).—Abundant in the coastal streams of southern California from the Santa Ynez [4] southward to the San Luis Rey.

Gila purpurea (Girard).—Known only from San Bernardino Creek, a tributary of the Yaqui River, in southeastern Cochise County, Arizona.

Klamathella, new subgenus

Scales small, shield-shaped at base, 60-70 in lateral line, with apical radii only; teeth 2,5-5,2; dorsal origin almost over insertion of pelvics.

Genotype.—*Gila bicolor* (Girard). Abundant throughout the Klamath River system of southern Oregon and northern California. The subgenus is named after this river. I have examined 39 pharyngeal arches of this species, including the type of *Tigoma bicolor* (USNM No. 234) and that of *Cheonda caerulea* (USNM No. 237), and recorded the following dental formulae:

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[2] Genotype of *Tigoma* Girard, designated (as *Tigoma pulchella*, a synonym of *G. nigrescens*) by Jordan, 1919: 270. I have examined only a few specimens of this species but strongly suspect that it does not range as far south into Mexico as published records indicate. If the southern form (or forms) proves to be distinct, then the Rio Grande species will stand as *Gila pandora* (Cope).

[3] The status of "*Gila*" *copei*, of the Bonneville and Upper Snake drainages and Wood River, has been treated by me (Miller, 1945).

[4] Probably introduced with a shipment of mosquitofish (*Gambusia affinis*) from the vicinity of Los Angeles. Also probably introduced into the Mohave River, a stream of the Great Basin in San Bernardino County, California.

2,5-5,2 in 34; 2,5-5,1 in 3; and 2,5-4,2 in 2. The types each have a formula of 2,5-5,2.

The species described below falls into the subgenus *Temeculina,* for its scales possess strong radii on all fields.

Gila ditaenia, new species

Plate I

DIAGNOSIS.—A rather fine-scaled *Gila* (63 to 75 in lateral line) with the scales bearing prominent radii on all fields, the mouth inferior, with 8 anal rays, and adults typically with two prominent dark bands along each side (whence the specific name, *ditaenia*).

TYPES.—The holotype, a breeding male 64 mm. in standard length, was collected by Ralph G. Miller in the Río Magdalena, 500 yards west of La Casita (which is about 25 miles south of Nogales, Arizona), Sonora, Mexico, on March 9, 1940; USNM No. 129954. Paratypes, 476, were collected as follows: 172 yearling to adult (USNM No. 129953) collected with the holotype; 9 young (USNM No. 129955) collected by Ralph G. Miller on March 9, 1940, from a small tributary of the Río Magdalena at Imuris (about 44 miles south of Nogales), Sonora, Mexico; 40 yearling to adult (USNM No. 45431) from Bear Creek (= Sycamore Canyon), a tributary of the Río Altar, near Oro Blanco, Santa Cruz County, Arizona, collected on December 3, 1893, by Edgar A. Mearns; 14 young to adult (USNM No. 130668) from Bear (= Sycamore) Canyon, in the Pajarito Mountains, Arizona, 4 miles north of the Mexican boundary line, collected October 9 to 12, 1944, by Professor Loye H. Miller; and 241 young to adult (UMMZ No. 141945) seined in Sycamore Canyon, a tributary of Río Altar, 14 miles west of Nogales, Arizona, by Marvin W. Frost and John Hendrickson on April 25, 1944. Eight specimens (USNM No. 130669) from a cemented spring in Bear (= Sycamore) Canyon, Arizona, were also collected by Professor Miller on October 9, 1944, but as these were probably planted in the spring and are somewhat emaciated, they are not designated as types. Sycamore Canyon is the modern name for Bear Creek or Canyon and is so marked (in R. 11 E., T. 23 S.) on the U. S. Forest Service map of Coronado National Forest, Arizona and New Mexico, edition of 1934.

DESCRIPTION.—The following description is based largely on an examination of all of the type material. The general shape and coloration are portrayed in Plate I, and the proportional measurements are given in Table I.

The form of the pharyngeal arch and the shape of the teeth are very similar to the arch and teeth of *Gila orcuttii* (Hubbs and Miller, 1943: 355-357, Pl. 3, Figs. 1 and 4). As in that species, the two limbs of the arch (measured from the base of the first and last teeth of the main row) are subequal; the lower limb near the teeth is narrow and rounded; the outer face of each pharyngeal bone has a narrow shelf for the insertion of the two smaller teeth; the last three teeth of the main row are expanded basally and the first three on the left side (and the corresponding two of the right side) are strongly hooked; often the next to last tooth of the main row on each side is hooked, but the last one is rarely, if ever, hooked. The anterior teeth of the main row have rather narrow, weak grinding surfaces, best developed on the third

tooth on each side. The dental formula is almost always 2,5-4,2, for although I examined the teeth of 30 individuals only two of these exhibited variant formulae: 2,5-4,3—with the three teeth of the right side perfectly formed; and 1,5-4,2—with the front tooth of the left side enlarged.

The scales are oval to nearly rectangular and closely resemble those of the genus *Rhinichthys* in having strong and numerous radii on all fields. The total number of radii varied from 33 to 51, usually 37 to 47, on 21 specimens from the type locality (Río Magdalena). Although *Gila orcuttii* does not have the scale radii so prominent or so numerous, those of *Gila purpurea* are even stronger than in the new species.

TABLE I

PROPORTIONAL MEASUREMENTS OF 21 MATURE ADULTS OF *Gila ditaenia*

	Holotype	Paratypes (USNM No. 129953)			
		10 Males		10 Females	
	Male	Range	Ave.	Range	Ave.
Standard length, mm	64	57— 79	66	76— 98	82
Measurements in thousandths of the standard length					
Dorsal origin to tip of snout	564	548—574	557	546—580	562
Pelvic origin to tip of snout	522	504—533	520	528—552	540
Anal origin to caudal base	334	328—343	337	319—340	327
Body, greatest depth	284	266—295	282	269—305	292
Greatest width	177	172—192	183	172—198	190
Head, length	285	279—294	287	284—320	298
Depth	187	180—200	192	188—206	197
Width	176	176—200	185	180—196	190
Caudal peduncle, length	221	216—239	228	204—229	213
Least depth	131	121—132	127	111—124	118
Interorbital, least bony width	76	72— 84	77	77— 93	85
Opercle, greatest length	91	91—101	95	98—105	102
Snout, length	93	87— 97	92	89—104	96
Eye, length	59	54— 65	59	54— 60	58
Mouth, width	90	83—100	91	85—111	101
Upper jaw, length	92	84— 91	87	85—109	95
Mandible, length	107	106—117	113	111—129	119
Dorsal fin, depressed length	251	228—252	239	207—236	219
Anal fin, depressed length	223	202—226	213	185—209	197
Pectoral, length	227	202—239	223	184—199	191
Pelvic, length	176	156—182	169	143—155	150

Gila ditaenia has short gill arches, with correspondingly restricted gill openings, and the short gill rakers, which are often very rudimentary anteriorly, number only 6 to 10 (ave. 8.0) as in *Gila orcuttii* (Hubbs and Miller, 1943: 358). The short gill slit and rakers are typical of most of the species of the genus *Gila*.

Fin-ray and scale counts for the new species varied as follows: dorsal 8, rarely 9; anal 8 (155 specimens counted); pectorals 15 to 17; pelvics invariably 8. Scales in lateral line 63 to 75, usually 65 to 72; dorsal to lateral line 15 to 18, usually 16; anal to lateral line 11 to 14, usually 12; pelvic to lateral line 9 to 11; predorsal 33 to 44, usually 36 to 42; circumference of

body [5] above, 34 to 41; circumference of body below, 30 to 37; total number of scales around body, 67 to 78, usually 70 to 75; circumference of peduncle above, 16 to 20; circumference of peduncle below, 15 to 19; total number of scales around peduncle 33 to 41, usually 35 to 39.

Coloration.—The specimens preserved in formalin on March 9, 1940, at the type locality, Río Magdalena, were received on March 20, 1940, with the breeding colors still well preserved. The axils of the pectoral and pelvic fins and the base of the anal fin were brilliant Chinese red, extending out onto these fins about two-thirds of their lengths, leaving a milky border on the outer margins. In some, there was faint evidence of red coloration at the base of rays 3 to 6 of the dorsal fin. The same red color was seen as a bright spot at the corner of the shoulder and also at the corners of the mouth, extending straight back to the posterior edge of the preopercle. The brightest fish were orange on the sides of the belly between the bases of the paired fins, and there was a diffusion of the same color over the ventral part of the caudal peduncle between the anal fin and the origin of the caudal rays. In noting these colors, the sexes were not separated, but the brightest fish were obviously males.

The smaller to medium-sized adults had two prominent, black lateral bands above and below the lateral line, the ventral one extending to the base of the anal fin and the dorsal band reaching to the caudal base. The cheeks had a bronze sheen. The general color tone was olivaceous to purplish or almost black above, the lower sides lighter, and the belly white.

Comparisons.—Only three species are now known in the subgenus *Temeculina*. *Gila ditaenia* differs from both *G. orcuttii* and *G. purpurea* in having much finer scales, 63 to 75 in the lateral line rather than 48 to 62, the range for this count in those two species.[6] The new species differs further from *orcuttii* in the bright red breeding coloration for such colors have not been observed in *orcuttii,* although I have collected spawning adults in Mohave River, California, and my father has collected great numbers during the spawning period in the coastal streams of southern California. I have not seen *purpurea* in breeding dress. *Gila ditaenia* differs prominently from its geographically nearest relative, *Gila robusta intermedia* (Girard), in the Santa Cruz and San Pedro river basins, Arizona and Sonora, in having a nearly horizontal rather than a definitely oblique mouth and in the much stronger radii (basal radii occasionally weakly developed in *G. r. intermedia*). The two prominent, black bands along each side of the body further distinguish *ditaenia* from its close relatives.

Habitat and Associates.—The habitat at the type locality was recorded in some detail by the collector. Río Magdalena near La Casita follows a bed about 75 to 100 yards wide. On March 9, 1940, the clear stream was 4 to 5 feet wide, about one foot deep, and with a fairly swift current over a bottom

5 This count is divided into a count above and below the lateral line on each side, not including the scales of the lateral line. Made in zig-zag fashion, the enumeration passes over the back about two scale rows in advance of the dorsal origin. The two counts are summed and two is added to this total to include the lateral line scale on each side. The scales around the caudal peduncle are similarly counted in zig-zag fashion around the slenderest part.

6 Counts for *orcuttii* based on Mohave and Santa Clara River material; those for *purpurea* based on the types (USNM No. 224) and topotypic material at the University of Michigan Museum of Zoology (UMMZ No. 141214).

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Adult male holotype, 64 mm. in standard length, of *Gila ditaenia*, USNM No. 129954. Retouched photograph.

of sand and gravel. The principal vegetation was watercress, found in backwaters along the stream. At 3:30 P.M. the air temperature was 66.4° F. and the water was 62.4° F. The bulk of the collection was made in a pool 3 to 4 feet deep which was formed by the roots of a fallen tree.

Other species seined at this locality were the minnow *Agosia chrysogaster* Girard, which was also abundant, and a few individuals of the cyprinodont *Poeciliopsis occidentalis* (Baird and Girard).

RANGE—*Gila ditaenia* is known only from Río Altar and Río Magdalena, which unite to form Río de la Concepcíon (also called Río Asuncíon). In flood, this river empties into the Gulf of California about 160 miles south of the mouth of the Colorado River. Although Ralph G. Miller has collected in many of the coastal streams of Sonora and Sinaloa, this species has not been taken elsewhere in that area and it is therefore probably confined to this single drainage. Moreover, although other species of *Gila* are found both north and south of Río de la Concepcíon, *ditaenia* appears to be the only representative of the genus in that basin.

SYNONYMY.—The only reference to the new species which I have been able to find is by Snyder (1915: 582) in which he provisionally identified the Bear Creek specimens (USNM No. 45431, see list of types herein) as *Richardsonius gibbosus* (now regarded as a synonym of *Gila robusta intermedia*).

ACKNOWLEDGMENTS.—The new species was first recognized from specimens secured by my father, Ralph G. Miller, during his energetic collecting in northwestern Mexico. Subsequently, Marvin W. Frost and John Hendrickson, while students at the University of Arizona, obtained a large series from southern Arizona. More than half of these specimens were turned over to the University of Michigan through the courtesy of Dr. Charles T. Vorhies; the remainder are at the University of Arizona. Additional specimens from southern Arizona were received from Professor Loye H. Miller of the University of California at Los Angeles, through Dr. Carl L. Hubbs, and valuable historical data were contained in Professor Miller's field notes.

SUMMARY

The species currently referred to the genus *Gila* are listed with their ranges, and tentatively grouped by subgenera. The subgenera are briefly diagnosed. One new subgenus, *Klamathella,* is proposed for *Gila bicolor.* A new species, *Gila ditaenia,* is described and figured. *Tigoma humboldti* is placed in the synonymy of *Richardsonius balteatus* and *Lavinia conformis* is regarded as a synonym of *Gila crassicauda.*

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Ichthyological Notes

STILL MORE FISHES THAT PLAY LEAPFROG.—In the issue of *The New York Times* of November 9, 1944, I read with a great deal of interest a review or condensation of a paper on this behavior of fishes by Dr. E. W. Gudger of The American Museum of Natural History in a recent issue of the *American Naturalist*. In his article Dr. Gudger suggested that it would be worth while for others to record like observations. Here is what I have seen of this curious behavior.

This past summer, in July and August, I was on vacation at Jamestown, Rhode Island. One day, I took a walk to the point where there was no beach but where the rocks dipped into the sea. Sitting there, I was idly watching the ripples in the water at the foot of the rocks. Floating on the water was a piece of wood about 8 inches long by 2 or 2½ inches wide, which was probably the float of a lobster box or trap. This swung to and fro with the movement of the water, but everything else round about was quiet. From where I was sitting, this piece of wood was about 15 feet away.

I had been there about 10 minutes when I saw a small fish jump over the piece of wood, clearing it entirely. Another one followed, and still another and another. There must have been a hundred, unless some of them leaped over and over again. Some vaulted completely over the piece of wood, others turned regular somersaults in the air. The less clever ones fell upon the piece of wood and slid off into the water. Sometimes two or three jumped over at the same time. The play went on for a good half hour, and the little fish really behaved like children having a good time.

I was especially interested because at the time I was reading Lecomte du Noüy's *Avenir de l'Esprit* in which he said that only mammals knew how to play. But these fishes certainly seemed to disprove his theory.

We were told that cameras were not supposed to be used at Jamestown during the war, and I was sorry to be unable to take pictures of these leapfrogging fishes.—E. Chinard, *Princeton, New Jersey.*

THE FROGFISH, *ANTENNARIUS SCABER,* USES ITS LURE IN FISHING.—It has long been assumed that the highest of the vertebrates, *Homo sapiens* (and he only in a comparatively late stage of his intellectual development), has devised a method of "fishing with an angle." But myriads of years before man, an animal belonging to the lowest group of vertebrates, a fish, *Lophius piscatorius,* had developed in connection with a flat head, a wide and slightly-upturned mouth beset with backwardly-pointing teeth, and hanging over the mouth a rod and bait—an efficient living lure and fish trap.

More than 2200 years ago, Aristotle, well named the Father of Natural History, described the use of rod and lure by the angler-fish, *Lophius piscatorius,* in its fishing. From the make-up of *Lophius* everyone has agreed that the tentacle and lure must be so used, but Aristotle's account has been doubtfully received because, so far as is generally known, no one has in all these long years repeated his observations and described this lure-fishing. However, becoming interested in *Lophius* from another angle, I have gone carefully into the literature and in articles whose titles give no hint of lure-fishing, I have dredged up four eyewitness accounts.

In 1929, Chadwick described this fishing in the tanks of the Marine Biological Station at Port Erin, Isle of Wight. In 1937, Wilson described the use of the lure by *Lophius piscatorius* in the Plymouth Aquarium and, earlier than either, Bigelow and Welsh (1925) quoted an eyewitness account of this fishing by *Lothius americanus* in open waters on the Massachusetts coast. Recently the fishing has also been observed in the Chicago Aquarium.

To get this behavior recorded in the literature under its distinctive title, I have worked up all data and have in press an article "The Angler-fisher, *Lophius piscatorius* et *americanus* Use the Lure in Fishing."

While at work on this article, Dr. C. M. Breder, Jr., told me of similar fishing habits of the dwarf angler or frogfish, *Antennarius scaber,* observed in the old New York Aquarium, and suggested that I look into the matter. I have done so, and this little article is written to put on record under a distinctive title the fishing with the lure by this *Antennarius.*

Personally, I have never had an opportunity to study this particular frogfish. But both at the U. S. Fisheries Laboratory at Beaufort, North Carolina, and at the Marine Laboratory of the Carnegie Institution of Washington at Tortugas, Florida, I have kept its near relatives, *Pterophryne histrio* and *gibba,* in aquariums. Neither has more than the rudiments of a lure and my interests were almost entirely centered in the production of the egg raft. Of the feeding of *P. histrio* at Beaufort I noted: "It fed voraciously, eating pieces of oyster, bits of shrimp, and small fishes alive or dead. In catching its prey, it would with closed mouth draw near, and then opening it suddenly (the premaxillaries and lower jaw protruding considerably) would take in its prey with an instantaneous gulp."

So far as this search has found, but one specimen of *Antennarius scaber* has ever been kept in an aquarium and its feeding habits observed and described. This fish was taken in Havana Harbor by Dr. William Beebe and his associates on the 1933 expedition of the "Antares" in the West Indies.

The feeding habits of this little tumid frogfish are briefly described by Beebe in his general account of the Expedition. I have urged him to write a detailed description of what he saw. But he is intently occupied with other work and has not only kindly turned over to me his material but has urged me to write up the habits as fully as I can and to use his figures. Here follows all that he has to say of these interesting fishing habits of the little frogfish ("On the *Antares* in the West Indies." Bulletin New York Zoological Society, 36, 1933: 115):

> In Havana . . . we secured one of the most interesting of the Angler fishes, *Antennarius scaber,* and brought it back alive to our New York Aquarium.
>
> Its lure was, in size, shape, color, and movement a perfect imitation of a wriggling grayish-white worm. While still on board the *Antares,* it devoured three of its own cousins, and a beautiful three-starred demoiselle. Twice I watched the process, and both times while the prospective prey was at least two inches away, the frogfish opened its mouth and with no apparent effort, created such a maelstrom, such an irrestible current, that the human eye could not see the fish disappear. It simply vanished from sight, the lure was tucked away and we imagined a gleam of satisfaction in the fishy eye.
>
> In the aquarium *Antennarius* was housed with a herd of sea horses but their armor proved no protection and three were forthwith devoured.

Beebe unfortunately did not describe with his usual meticulous accuracy the details of the fishing (particularly the action of the lure). When urged to go back in memory

for these things, he says that (as for all of us) much other work since has crowded these details out of mind. However, he states that the tentacle was moved about actively (as also reported for *Lophius* in the accounts above referred to) and that the "bait" much resembled a swimming or wriggling worm.

This little fish fed in the same fashion in a tank of the old New York Aquarium, and fortunately three excellent photographs of it were obtained. These and their (original) captions (which are retained) make the process quite clear. In Figure 1 note that the fishing apparatus (illicium—new Latin, an allurement) is composed of a rod (tentacle or antenna—whence *Antennarius*) and a worm-shaped lure attached in its middle region to the antenna. This fishing rod is a first dorsal spine moved forward to a position just above the upper jaw and transformed into an angling apparatus and, as has been shown in Beebe's text and figures, a most effective one. The rod is hinged to the skull by its moveable base and to this are attached tiny muscles. These things give the rod perfect mobility. It is interesting to note just here that this excellent photograph (Figure 1) shows the antenna of *Antennarius scaber* to be marked with light and dark bands. This banding was, so far as I know, first figured and described by Cuvier (Mémoires Museum d' Histoire Naturelle, Paris, 1817: 426, pl. 16. fig. 2). The figure shows the annulations plainly and of the banded filament he writes: *"Le premier rayon ou le filament de la tête est marqué d'anneaux bruns et blanchâtres."* His figure shows the bait very much like a worm tethered in the middle region.

Figure 1 from Beebe shows *Antennarius* evidently twiddling its lure. This attracts the little fish, which is coming down to investigate. In Figure 2, the victim draws closer to the lure—and to its doom. In Figure 3 the investigator has disappeared—an X-ray photograph of the fisherman would probably show its present location. The happy (because well-fed) fisherman has laid rod and lure back on the midline of the head, and has spread his fins widely. This is an excellent photograph of the successful angler.

Other than the above, references to the angling apparatus of *A. scaber* are few (so far as I can find), but I am privileged to quote two:

At Tortugas, long after my stay there, Longley had two specimens in an aquarium. He records no feeding by them, but of the illicium he writes (Longley and Hildebrand: "Systematic Catalogue of the Fishes of Tortugas, Florida." *Papers Tortugas Laboratory,* 34, 1941: 304). "The base of the fishing rod is advanced beyond the margin of the upper jaw. The rod is considerably longer than the second spine, and the bait is bifid, fleshy, a third as long as the rod, and singularly worm-like. When not in use it is coiled up and pressed in a hollow behind the second spine." Something like this is shown in Figure 3.

Last to be quoted is John Tee-Van, who has given me (personal communication) the following statement of his observation on an *Antennarius* which to the best of his recollection was *scaber*:

> Somewhere in the middle 1930's during the years of the Bermuda Oceanographic Expeditions, I recall being shown by Louis Mowbray, Sr., two specimens of a Frogfish that he had in one of the exhibition tanks of the Bermuda Aquarium. The two fish were resting among the interstices of the rocks at either side of the tank, probably five feet distant from each other.
>
> One of them was not more than 12 inches from the glass front of the tank, where it could be easily observed. This individual was headed toward the center of the tank and demonstrated a great deal of interest in some small specimens of so-called "Bermuda mangrove mullet" (*Fundulus bermudae*). Each time that one of these little fishes approached within a couple of feet of the Frogfish the latter alerted itself by pushing up the front of its body by tensing the pelvic fins, while at the same time it moved its illicium back and forth in line with the axis of its body. The so-called bait appeared to be considerably distended and somewhat larger than is normally seen in preserved specimens of *Antennarius*. The result was that as the antenna moved forward the lure trailed behind, and this bait reversed its movement when the tentacle moved back over the fish's mouth. This trailing back and forth resembled the waving of a handkerchief held in the middle. Each time that one of the little killifishes came within a foot or so of the frogfish the action was repeated.
>
> Unfortunately I was not able to witness the catching of the small fish, but judging by my observations of the feeding of another Antennariid, *Histrio histrio,* I would say that the Killies were in danger whenever they came any wise close to the frogfish.

In this article on *Antennarius scaber* and in that on the two species of *Lophius,* it has been shown that each fish possesses an illicium (whiplash and lure) and that each uses this apparatus to attract other fishes, which when enticed close enough are gulped down. From this evidence the sound conclusion may be drawn that all those members of the order Pediculati, which have this angling apparatus, use it in fishing. All that is needed is the publication of like observations on other members of this group of fishes, and one of

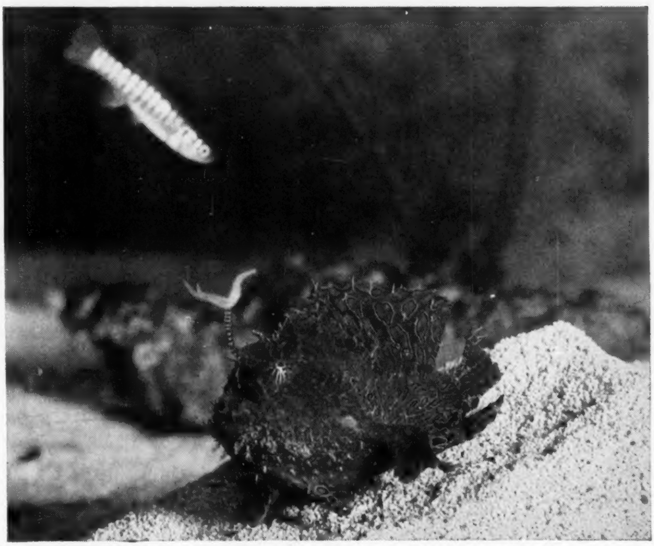

Fig. 1. The spotted anglerfish, *Antennarius scaber*, is awaiting its prey. Directly above the nose of the angler is the lure, a perfect imitation of a wriggling gray worm, attached to a short, flexible tentacle. Above is a fish coming down to investigate the lure. After Beebe, 1933.

Fig. 2. The frogfish attracts its prey by violently moving the worm-like lure. When the prey has moved into the direct sphere of possibility, the great mouth of the angler opens and in the current created the minnow is engulfed so quickly that the eye cannot follow it. After Beebe, 1933.

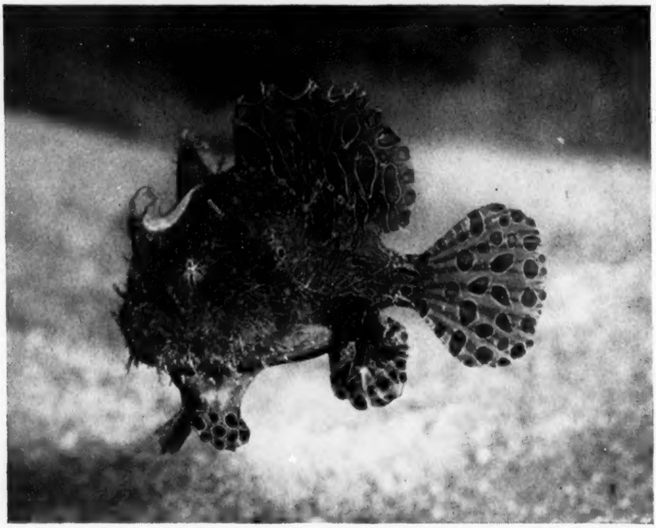

Fig. 3. The happy anglerfish, with the lure laid back on the head and with all fins spread is like a peacock on display. After Beebe, 1933.

the purposes of this article is to incite the bringing to light of such observations and thus to extend our knowledge of this fishing habit in the Pediculate fishes.—E. W. GUDGER, *American Museum of Natural History, New York City.*

AMPHIOXI SWIMMING IN A CHAIN.—When Dr. C. M. Breder had read my article, "Fishes that Swim Heads to Tails in Single File," published in the September issue, 1944, of COPEIA (152–154), he called my attention to the figure in Lydekker's "Royal Natural History" and his other like works, showing Amphioxi swimming in a chain. Unfortunately I had never seen this figure, nor the account which lead to the portrayal.

It is also very unfortunate that, with the shortsightedness of many who write popular books on natural history, Lydekker contented himself with saying (Royal Natural History, London, V, 1896: 560) of their movements, that: "According to another observer, lancelets occasionally attach themselves to one another by their mouths in a chain-like manner, as represented in our illustration" (Figure 1)—and nothing more. Had Lydekker merely put after "observer" the citation—W. R. Wilde, 1840—considerable effort would have been saved in clearing up the reference.

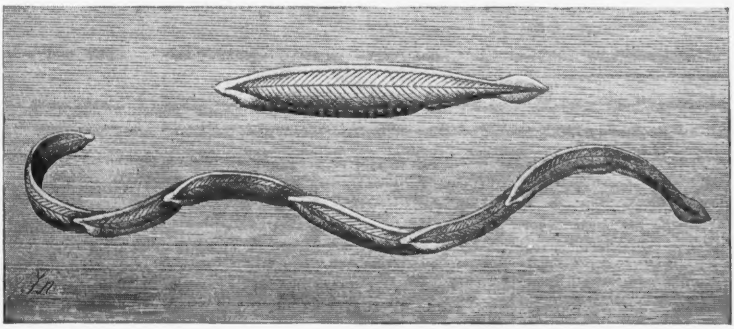

Figure 1. The lancelet shown singly and also in a swimming chain. After Lyddeker, 1896.

The technique of this figure somewhat resembles that which characterizes many figures found in William Yarrell's "History of British Fishes." So I went to the 2nd edition (1844: 625), where under "Lancelet" I found not the figure but a reference to and a long quotation from Wm. R. Wilde, "Narrative of a Voyage to Madeira, Teneriffe, and along the Shores of the Mediterranean," etc. (Dublin, 1840). Yarrell specifically quotes Wilde as follows:

> These little animals [Lancelets] had a power of attaching themselves to each other in a remarkable manner, sometimes clustering together, and at others, forming a string six or eight inches long; the whole mass seemed to swim in unison, and with great rapidity, going around the vessel in a snake-like form and motion. They adhered to one another by their flat sides; when in line the head of one coming up about one-third on the body of the one before it; no doubt these sides are of use in forming this attachment.

On procuring a copy of Wilde's book, I found that Yarrell had quoted verbatim from his Vol. I, Appendix E (427)—which Lydekker had not done. This observation was made at Algiers some time between December 19–28, 1837. I had hoped that Wilde's book might have an illustration portraying this most curious and interesting behavior, but there is none. Presumably the figure was drawn for Lydekker's book.

This figure and brief account are also found in Lydekker's "Library of Natural History" (New York, V, 1902: 2935), but nothing new is added. Dr. Breder tells me that he has seen this figure in other books, but cannot recall what these are. I greatly regret that figure and account did not head my other article. Under the circumstances it seems well to publish the figure and my note that this curious behavior may be cited in the literature under its proper title.

The point may be made that this one alleged observation of this curious behavior of *Amphioxus* has never been verified by any other observer. This seems unfortunately

true, for the literature on *Amphioxus* has been carefully searched without finding any corroboratory evidence, or even reference to Wilde's observation—which seems to have been completely overlooked. This is an additional reason for publishing this note.

But the question may also be asked who was Wilde and what standing had he? To this query there fortunately is an answer. Wilde was an eminent Irish surgeon, who became surgeon-oculist to Queen Victoria and because of his services was knighted in 1864. He wrote several books on surgery (particularly of the eye and ear). He is also the author of various other works including at least one travel book—that noted above. As to the standing of the work quoted, it may be mentioned that it is listed in the printed catalogue of the British Museum (Natural History).

All the above leads to the conclusion that at least some credence must be given to Wilde's recorded observation.

I suspect that swimming by fishes in chains is probably more common than is thought. And it is hoped that the publication of these two short articles on tandem swimming may lead others who have witnessed this behavior in *Amphioxus* or in fishes to publish their observations, and thus establish it as a normal phenomenon in the life of these animals.—E. W. Gudger, *American Museum of Natural History, New York City.*

WINTER HABITS OF NORTHERN LAKE MINNOWS.—So little has been recorded concerning the winter habits of the minnows which dwell in our northern lakes that the following observations, limited as they are, should be of some interest.

Apparently most fishermen (and biologists?) hold the general opinion that minnows normally dwelling in the northern lakes try to find open water during the period of freeze over, seeking a more comfortable habitat in tributary streams. This is, of course, not always possible. Neither is it always true where excellent opportunities exist for this means of escape. Lake Mendota, uppermost of the Yahara River chain of lakes, at Madison, Wisconsin, provides ice-free water throughout the winter in the upper Yahara River, in Spring Harbor and in several other places. Great concentrations of the bluntnosed minnow, *Hyborhynchus notatus,* and of the western banded killifish, *Fundulus diaphanus menona,* occur in Spring Harbor each winter, and the river teems with small fish of various species, but recent evidence lends support to the belief that great numbers of minnows remain in the lake.

Fishing through the ice for yellow perch is a major sport on Lake Mendota. Many thousands are caught each winter. Frequently perch brought up from depths of 35 to 60 feet will regurgitate from one to four minnows onto the ice. Fishermen generally attribute this to the fact that they have caught a "bait stealer," minnows being a favorite bait here during the early winter. I have examined a number of these regurgitated minnows. They bear no hook marks and consequently are not bait, but represent natural food. Since the minnows are effective as bait when fished near the lake bottom in this depth of water it is only logical to assume that their effectiveness is due to the fact that natural populations exist at those depths and feed along the bottom and in turn furnish food for the perch.

The most common species recovered from the perch is the bluntnose minnow, *Hyborhynchus notatus,* but on January 21, 1945, I noticed that many perch had regurgitated one or more small lake emerald shiners, *Notropis atherinoides,* a species not considered very common in Lake Mendota.

On January 28, 1945, my fishing partner, Mr. Louis Marshall, had several bites on a small hook baited with the larvae of the goldenrod gall wasp, while fishing in 50 feet of water, just off the lake bottom at that point. He finally succeeded in hooking a large specimen of the western spottail shiner, *Notropis hudsonius selene.* There was obviously a large school of these minnows working along the lake bottom and actively feeding. I have, incidentally, never seen this extremely abundant species in the Yahara River or the tributary spring fed streams during the winter months.

It is worthy of note that minnows cease to be an attractive bait and are replaced almost entirely by the goldenrod gall wasp larvae late in the season when the perch are caught in the oxygen depleted waters of the deeper portion of the lake (80 feet), probably because the minnows cannot live in this region and the perch are no longer utilizing them as a natural food.—John D. Black, *Wisconsin Conservation Department, Madison, Wisconsin.*

A SPECIMEN OF *ENGRAULIS MORDAX* GIRARD LACKING VENTRAL FINS.—While collecting some samples of the northern anchovy (*Engraulis mordax* Girard), I found a specimen (122 mm. standard length) in which the ventral fins are entirely absent. It was taken incidentally in a sardine haul by the boat "Ocean Queen" off Davenport, Santa Cruz Co., California (approximately 37° 00′ 00″ N. Lat., 122° 14′ 00″ W. Long.), at 11:00 P.M., January 4, 1945. This specimen is now Stanford Natural History Museum No. 39789.

There are records of the complete or partial absence of ventral fins (with corresponding modifications of the pelvic girdle) in various groups of fishes, and probably many more observations on this anomalous condition which are not in the literature. It is apparent that this phenomenon is of taxonomic and evolutionary significance. Dr. G. S. Myers, Stanford University, has indicated that a study of the significance and importance of this mutation is in progress.

In addition to calling attention to the lack of ventral fins in a specimen of *E. mordax*, this note has been prepared with the aim of stimulating others to publish observations of a similar nature.—JOHN C. MARR, *Fish & Wildlife Service, Hopkins Marine Station, Pacific Grove, California.*

Herpetological Notes

HERPETOLOGICAL NOTES FROM ALLEGANY STATE PARK, NEW YORK.—During the summer of 1944, in Alleghany State Park, Cattaraugus County, New York, the writer, aided by Mr. Richard W. Russell, obtained a few new records for the area and observed certain changes in abundance which appear to have taken place since the publication of Bishop's handbook (Bishop, S. C., 1927, New York State Museum Handbook No. 3).

Eurycea l. longicauda (Green).—Upper Red House Creek, under log, Aug. 17; Wolf Run, under stone in pasture, Aug. 18.

Rana catesbeiana Shaw.—Now common in Red House Lake (about one-half square mile in area, dammed in 1929); reported by Bishop, 1927, only from Tunungwant Valley because at that time there were no adequate ponds in the Park.

Thamnophis butleri (Cope).—Vicinity of Red House Lake; Wolf Run (5 taken Aug. 18, mostly under planks and stones in pasture). This snake is not uncommon now in favorable situations. Perhaps the population has increased, for Bishop gives only one record, the first for the state and the Park.

T. s. sirtalis (Linnaeus).—A partial albino, half-grown, found about Aug. 1 along Limestone Brook. The general color was light buff, with lateral stripes and dorsal spots faintly indicated in orange. The specimen was destroyed by a visitor at the zoo.

Chelydra serpentina (Linnaeus)—Like the bullfrog, the snapping turtle is now common in Red House Lake. Two or three were noted in the creek below, and one was found in France Brook, a higher branch.

Terrapene carolina (Linnaeus).—One taken in Red House Valley just below the Park limits in late June.

Amyda s. spinifera (LeSueur)—Two from Red House Lake. Unknown from the Park in 1927, the soft-shelled turtle has been found several times in the last ten years, according to local reports, in Red House Lake, the creek below it, and the Allegheny River.—THEODORE H. EATON, JR., *Dept. of Biology, The University of Buffalo, Buffalo, New York.*

THE HATCHING OF *LEIOLOPISMA LATERALE.*—On July 12, 1944, Lewis Follansbee brought to me a nest of the harvest mouse, *Reithrodontomys fulvescens,* along with two of the young mice, which he had found near College Station, Brazos County, Texas. The nest was located in an abandoned burrow of a pocket gopher, *Geomys brevi-*

ceps, at the base of a shrub, *Ilex vomitoria.* The mother of the young mice was in the nest at the time it was found, but she escaped capture.

While examining the nest, which was composed of dry shredded grass, largely *Andropogon,* I noticed three small opaque, ovoid objects. One was slightly torn so I picked it up, whereupon a small *Leiolopisma* emerged and immediately began crawling about in my hand. Its movements were rapid, as much so as in the adult. Time: 1:15 P.M. Within five minutes another egg began to hatch. The young lizard punctured the membrane egg shell with its nose, pushed its head completely outside and then rested for about 15 seconds. The rest of the body soon followed. The third egg hatched before the second lizard had completely emerged from the shell. The hatching of the three eggs involved no more than 15 minutes.

The eggs measured approximately 5 x 7 mm. The young lizards averaged 47 mm. in total length; tail, 28 mm. On comparison with adults that had been preserved in alcohol for several years, the color and pattern of the young appeared the same except that the brown of the newborn young was paler.—WILLIAM B. DAVIS, *Department of Fish and Game, Agricultural and Mechanical College of Texas, College Station, Texas.*

OBSERVATIONS ON THE FEEDING OF THE COMMON KING SNAKE.—The result of placing a 3-foot corn snake (*Elaphe guttata* Linnaeus), in the same room with a captive 4½-foot common king snake (*Lampropeltis getulus getulus* Linnaeus), on May 8, 1944, is here reported. Both snakes lay perfectly motionless for several minutes. The king snake moved first, and at its action the corn snake started violently, whipped its head around, and actually seemed to "bound" across the room in a dash to escape.

The corn snake was next presented by holding it in my hands about 4 inches from the snout of the aroused king snake. The latter immediately seized the rapidly moving tail and rolled two coils about the posterior quarter of the body. The initial seizure occurred at 2:40 P.M. For the following ten minutes the king snake moved its snout along the body of its victim, flicking the tongue constantly over the scales. The corn snake lay out-stretched, its head as far as possible from that of its captor, and made the regular undulant motions of crawling. It made no violent movements. At 2:50 P.M. a second seizure was made slightly forward of the middle of the body. The corn snake coiled and uncoiled twice and in approximately one minute the king snake had imprisoned a double loup and had three tight coils around it. At 2:55 the king snake abandoned its mouth grasp but tightened the coils noticeably. Keeping the head slightly arched, with the snout against the floor and tongue moving steadily, it began to crawl around its own coils apparently searching for the head of its victim. Several times the corn snake was nearly grasped; it escaped by swinging the head and the free 10 inches of body on the opposite side of the tangle. At one time the heads of both were no more than 2 inches apart, but the king snake made no effort to attack; instead it moved slowly around its coils following the previous path of the corn snake, and approached from the opposite side.

At 3:04 the third seizure was suddenly made 2 inches behind the head; the coils did not shift or relax. For the first time the corn snake bit the nearest coil viciously and retained its hold. At 3:10 the king snake began to work its mouth down the neck to the head. At 3:14 the corn snake was held directly behind the temporal plates and in three steady, successive pulls its teeth were ripped loose from the encircling coil. The king snake now worked its mouth over the other's snout with no resistance.

Actual swallowing began at 3:17. The king snake was so doubled up on itself that it had to pass through its own coils to engulf the first 18 or 20 inches, relaxing them for the purpose. Twice during the procedure curious squeaks were distinctly audible, perhaps produced by air escaping through the flattened glottis; they did not sound like the rubbing of scales. Swallowing proceeded slowly at first but quickened noticeably after the middle of the body had been reached. At that time the tight coils were entirely relaxed, the body was straightened out and the king snake finished the meal lying at full length. At 4:00 swallowing was completed and the tail of the corn snake had disappeared. At once the king snake began moving about, "yawning" and rubbing the sides of its jaws on the floor.

During the entire encounter the presence of two observers in the room did not appear to disturb either reptile, even when vibrations were made by walking on the floor. The time from initial seizure to completion of swallowing was 1 hour and 20 minutes.—RICHARD C. SNYDER, *Camp Rucker, Alabama.*

APPLICATION OF THE NAME *ELEUTHERODACTYLUS RICORDII*.—Some years ago while identifying a collection of Cuban amphibians made by P. J. Darlington, I came across several specimens of an *Eleutherodactylus* from the eastern highlands that appear to differ from other members of the genus known to me. Except for coloration, and perhaps slightly larger size, they are very similar to what has long been known as *Eleutherodactylus ricordii*, whose type locality is Cuba, and whose currently accepted range includes all parts of Cuba and several of the Bahama Islands. As, however, the color of the highland specimens agrees essentially with that given in the original description of *ricordii*, the suspicion was aroused that they really represent true *ricordii*.

I therefore restrict the name *ricordii* to the form from the highlands of Oriente, Cuba, which has a spotted dorsum. The color is: Above, ground color whitish or brownish white, heavily spotted with dark brown, the spots rounded and frequently coalescing, those on limbs in general smaller. In some the spots coalesce to such an extent as to give the impression of marbling. This is especially true of frogs from the Upper Ovando and El Yunque de Baracoa which may represent a distinct race. Below, whitish or light brownish. The largest example has a head and body length of 36 mm. This form is represented in the Museum of Comparative Zoölogy by the following specimens:

M.C.Z. 3122.	Monte Libano, Guantanamo, no altitude given.
M.C.Z. 21946.	Gran Piedra Range, 2000–3000 ft.
M.C.Z. 21961–4.	Near Cueva del Aura, Pico Turquino, 1500–4000 ft.
M.C.Z. 22080–1.	El Yunque de Baracoa, 1000–1800 ft.
M.C.Z. 22150.	Cobre Range, Sierra Maestra, 3000–3800 ft.
M.C.Z. 22169.	Upper Ovando River, 1000–2000 ft.

All these localities are in the Province of Oriente, and the frogs, with the exception of the first, which was taken by C. T. Ramsden, were all collected by P. J. Darlington. Possible confirmation that the highland form is the one originally described as *ricordii* by Duméril & Bibron, is to be found in the fact that, according to Dr. Darlington, French settlements formerly existed at one or more of the localities where he collected.

For the form widespread in Cuba and the Bahamas hitherto called *ricordii*, the name *Eleutherodactylus planirostris* (Cope) is available. Its type locality is New Providence Island, Bahamas. It is *planirostris* therefore, that is now present in Florida as an introduction. On account of the nature of the differences existing between *ricordii* and *planirostris* (as used here), it seems better to use the two names in subspecific relationship, although in the material at hand there is no real evidence of intergradation or hybridization. This may be shown to occur eventually as there is some evidence of hybridization between *planirostris* and the species *casparii*, of the Trinidad Mts. in Cuba, where their ranges meet, a seemingly parallel situation.—BENJAMIN SHREVE, *Museum of Comparative Zoology, Cambridge, Massachusetts.*

OTOLITHS OF *XENOSAURUS*.—It has long been well known that the age of certain fishes could be determined by a study of the lamellar structure of the otoliths. The discovery of the presence of otoliths in the lizard *Xenosaurus grandis* thus suggests the possibility of determination of age in these animals as in fishes. If such a method were to prove feasible it would provide an accurate method of age determination in wild-caught lizards. It is to be assumed that bone structure may well be useful for this purpose in lizards as Bryuzgin (1939, Comptes Rendus Acad. Sci. URSS, 23(4): 403–405, figs. 1–4) has shown it to be in snakes.

The otoliths in *Xenosaurus* are of relatively large size, occupying perhaps one third of the volume of the inner ear cavity. They are lenticular and concavo-convex in cross section, and the flattened surfaces are roughly oval in outline. The measurements are, approximately, 2.5 mm. in length, 2 mm. in width, and .9 mm. in thickness. A knob-like projection extends ventrolaterally into a depression that houses the lagena. The otoliths have a chalky, crystalline texture and are pure white in color. Grossly estimated, their hardness seems to be about equal to that of ordinary writing chalk.

Polishing upon a fine stone and glass failed to disclose any evidence of annular structure. Surfaces polished at various angles revealed no differentiation whatsoever in structure. Treatment in glycerin and a carbon suspension likewise failed to yield positive results.—HOBART M. SMITH and LEONARD E. LAUFE, *Biological Laboratories, University of Rochester, Rochester, New York.*

VARIATION IN LENGTH OF NEWLY-BORN GARTER SNAKES.—On August 1, 1940, a common garter snake, *Thamnophis s. sirtalis* (Linnaeus), was collected from a meadow at the junction of Richardson and Egyptian Hollows, Pike County, Ohio. The specimen measured 914.4 mm. (36 inches). On August 6, this snake produced a litter of 57 young. The time of delivery was approximately 1.5 hours, beginning at 11:30 A.M. and terminating 1:00 P.M.

Conant (1938, Amer. Midl. Nat., 20: 107) reports that Ohio females of *Thamnophis s. sirtalis* gave birth to young on dates ranging from July 3 to August 1, and that the number of young in the births ranged from 14 to 30. He cites a 37-inch female that contained 39 embryos, and a 44-inch specimen with 33. Thus the case reported here seems to be a late birth of an unusually large brood.

During the five days of captivity before parturition the specimen ate readily of eathworms (*Lumbricus* sp.) and small frogs (*Rana clamitans* and *Rana pipiens*). The snake was kept in a large terrarium case which simulated natural conditions.

Of the 57 young delivered, three specimens were stillborn, and were not observed to make any efforts at all to move in their egg membranes. Two others escaped shortly after freeing themselves from their membranes, and the remaining 52 snakes were measured for total length.

The total lengths of the newly-born snakes ranged from a minimum of 169 mm. to a maximum of 203 mm., a maximum range of 34 mm. The average length was 188.4 mm. The snakes were listed in order of length, and the median specimens were both 189 mm. long. Median length and average had a difference of only 0.6 mm.

Quartile deviation (in which the first and last quarters of the snakes, listed in order of size, are discounted) indicates that the central 50% of the lengths of the young *Thamnophis s. sirtalis* range only from total length of 184 mm. to 192 mm., a range of 8 mm.

FREQUENCY DISTRIBUTION

Total Length (mm.)	Number of Cases	Total Length (mm.)	Number of Cases
166 to 170	1	186 to 190	14
171 to 175	2	191 to 195	14
176 to 180	3	196 to 200	2
181 to 185	12	201 to 205	4
		Total	52

The lower 37.5% of the range of length, from 166 mm. through 180 mm., includes 11.6% of the snakes. The upper 25%, from 196 mm. to 205 mm., includes another 11.6%. The remaining 76.8% of the juvenile snakes have lengths from 181 mm. to 200 mm. (the remaining 37.5% of the total length range). The frequency distribution chart shows a strong central tendency in the measurements of total lengths of newly-born *Thamnophis s. sirtalis.*

Conant (*loc. cit.*) records newly born specimens measuring from 6¼ to 7⅞" in length, i.e., from 158.8 mm. thru 200.0 mm., with a total variation of 41.2 mm.—JOHN THORNTON WOOD, *Dayton Public Museum, Dayton, Ohio.*

OCCURRENCE OF THE DUSKY SALAMANDER ON MANHATTAN.—On May 5, 1944, eleven specimens of the dusky salamander, *Desmognathus fuscus fuscus* (Rafinesque), were collected on the bluffs overlooking the Harlem River, between 181st and 190th Sts., on Manhattan Island. They were found under rocks lying in and adjacent to several small springs, descending the hillside at this point. They include adults, as well as specimens still in the gilled stage. While eggs have not been observed, the species evidently breeds at this locality, because of the large number of larvae observed each year. Three specimens of *Storeria dekayi* were collected by the author in the same locality during 1942, and there is one doubtful record for a young *Thamnophis sirtalis sirtalis.*

The only previous record of the occurrence of this species on Manhattan proper is in Rafinesque's original notes on "Triturus fuscus (nebulosis)" (Ann. Nat., Lexington, Ky., No. 1, 1820: 4–5) in which the author mentions Harlem and Long Island as the locality of specimens.

The colony has been observed for three years and seems to be holding its own despite the number of people passing through the park daily, and it is to be hoped that collectors will allow the colony to remain intact in the future.—CARL GANS, *125 Cabrini Blvd., New York 33, New York.*

A COLLECTION OF REPTILES FROM KWEICHOW PROVINCE, CHINA.—Kweichow is the *terra incognita* of southern China; in his 1935 monograph, "The Reptiles of China," Pope lists material from only two localities of this remote province. The present collection adds one lizard and three snakes to Pope's records. The material comes from three localities with North latitude and East longitude readings as follows:

Kweiyang:	26.18 and	106.40
Meitan:	27.41 "	107.43
Tsunyi:	27.35 "	107.2

Amyda sinensis (Wiegmann).—One Meitan specimen with carapace and tail measuring 98 and 14 mm.

Gekko subpalmatus Günther.—One Tsunyi specimen with a total length of 124 mm., half of which is occupied by the body. Pope does not record this lizard from Kweichow.

Natrix tigrina lateralis (Berthold).—Five Meitan specimens, the largest of which has a body 752 mm. long. The range of ventrals in these, plus an additional individual from Kweichow, is 150 to 156. The scales of all are in 19 rows anteriorly and at mid-body, 17 before the vent.

Opisthotropis lateralis Boulenger.—One Meitan female measuring 367 + 94 mm. has the following characters: 27 maxillary teeth; nasals undivided; loreal longer than deep; preoculars and subpreoculars single, postoculars 2; temporals 1 + 2; 9 upper labials, 5th and 6th entering eye; 4 lower labials in contact with anterior chin-shields; scales in 17 rows, striated and feebly keeled, with minute asperities, keels stronger on tail; ventrals 152, anal divided, subcaudals 57; olive gray above, yellowish white beneath, the two colors sharply defined by a black line running along the third series of scales and extending to the eye. This species was previously known only from eastern Kwangsi in China and from Tongking (Pope).

Elaphe mandarinus (Cantor).—One small Meitan male; also a large Kweichow male measuring 782 + 166 mm. There are from 14 to 16 teeth on each maxilla.

Elaphe carinata (Günther).—One Meitan specimen measuring 1446 + 339 mm. has 223 ventrals and 92 subcaudals; the scales are keeled and in 23 rows anteriorly, 25 at mid-body, 19 posteriorly. Each maxilla bears 16 teeth. Pope does not record this snake from Kweichow.

Elaphe taeniurus Cope.—Twelve specimens from Meitan, Tsunyi, and Kweiyang have the following measurements (in mm.) and scale counts:

Length	Ventrals	Subcaudals	Upper Labials
1034 + 285	248	106	8
948 + 164 +	242	63 +	9
1434 + 312 (+?)	242	87 (+?)	8
1379 + 331	258	111	9
1116 + 261	238	104	9
962 + 155 +	260	60 +	8
1336 + 330	245	113	9
1296 + 348	238	113	9
325 + 89	247	123	9
347 + 97	246	123	8
387 + 101	247	116	10
378 + 92	246	117	9

Each maxilla bears 21 or 22 teeth.

Opheodrys major (Günther).—The four Meitan specimens have the following measurements (in mm.) and counts:

Length	Ventrals	Subcaudals
522 + 197	169	91
697 + 250	168	89
467 + 169	176	93
582 + 186	175	76

The scales of these specimens are in 15 rows throughout and each maxilla has 21 or 22 teeth. Pope does not record this species from Kweichow.

Amblycephalus boulengeri Angel.—Two females from Meitan measure 350 + 90 and 221 + 52 mm. One has 184 ventrals, 68 subcaudals, and 6 maxillary teeth. Kwei-

chow is the type locality of this species, which has also been recorded from the region of Wanshien, Szechwan (Pope).—YUHSI MOLTZE WANG, *Zoological Laboratory, National University of Chekiang, China.*

A NATURAL HABITAT OF THE HOUSE GECKO (*HEMIDACTYLUS MABOUIA*) IN BRAZIL.—In tropical countries, certain geckos have become so closely and commonly associated with the habitations of man that one comes to think of them purely in this association and to forget that the endemic species, at least, must have lived in other places before man provided them with an artificial habitat. Of these "house geckos" the majority of specimens collected by naturalists are from houses and the collector frequently sees them nowhere else. This is especially true in continental localities in or near rain-forests, where the number of ecological niches is so large and their character so varied that any attempt to locate the unknown natural habitat of any particular small animal is difficult.

My introduction to the wide-spread American (and African) house gecko, *Hemidactylus mabouia* (Moreau de Jonnès), took place on a table top in the best (but scarcely recherché) cafe in Santa Cruz, Bolivia. Later I found the species common in Rio de Janeiro, although records of it from this region are few. They were not seen during the cool months (May to October) but with the advent of really hot weather, individuals frequently appeared in my apartment, near Praia Vermelha—on the walls, or floors, or bedroom dresser. They are most commonly seen on the outside walls of houses, on stone fences, or on tree trunks along the streets, from dusk to about ten o'clock. This species was also observed abundantly on houses in the Tijuca residential section of Rio, and in Santa Teresa, Espirito Santo.

Recently I discovered a natural habitat in which the species seems to be very common. Gavea beach, just west of Rio, is backed by scrub growth, among which there are a few dozen plants of the giant agave, *Fourcroya gigantea,* some of them reaching a height of at least 12 feet. Nearly every plant was found to harbor one or two adult *Hemidactylus,* hiding down between the bases of the more closely appressed central leaves. This is also the chosen habitat of a peculiar, flattened spider, which scuttles around the axis of the plant with amazing agility. The plants are so huge and the leaves so strong that it was impossible to part them on the largest plants, but in smaller plants a man can wedge himself between two leaves, and, after bending down some of the inner ones and getting them under his armpits, he can use both hands to part the center leaves and catch the geckos. Luckily for would-be collectors the leaves have few marginal spines. All the plants showed gecko droppings, although some had no geckos. Those agaves (*piteiras* in Brazil) in which the newer central leaves had not yet detached themselves from the central spike, had no safe retreat for the animals and none were found in them. Evidently the animals temporarily desert such plants for safer places.

Examination of fourcroyas on the Restinga de Sernambetiba, in the western part of the Distrito Federal, showed that nearly all of these also harbored *Hemidactylus,* and it now seems certain that these great plants are inhabited by geckos wherever the latter exist. There has been some controversy over the endemic status of *Fourcroya gigantea* in Brazil, but certain factors too involved to enter into at this time make me certain that the plant is native. Recent botanical writers agree with this, and the habitat is a natural one.

Finally, while travelling through southern Brazil, I examined fourcroyas behind the beach some 10 miles south of the estuary of Paranaguá, Paraná, and collected *Hemidactylus mabouia* from them. This is by far the southernmost record for the species along the Brazilian coast.—GEORGE S. MYERS, *Museu Nacional, Rio de Janeiro, Brazil.*

FOOD OF SOME AMPHIBIANS AND REPTILES OF OREGON AND WASHINGTON.—Examination of the stomachs of specimens collected in Oregon and Washington in the summer of 1935, yields the following data.

Rana pretiosa pretiosa (Baird and Girard).—The western frog is for the most part semi-aquatic in habit. Thirty-seven specimens were taken in damp meadows and along the margins of streams and lakes. No really dense populations were encountered. It may

be for this reason that the incidence of ascarid parasitism was light. Only 2 frogs were infected. Insects form a large part of the diet. In striking at insects, bits of the substrate stick to the tongue, and thus wood chips, fir needles, spikes of *Carex*, bits of grass, earth, leaves and pebbles are found in the stomachs. Many aquatic and paludicolous insects make up the diet of this frog, more so than in the northwestern toad which inhabits much the same region.

The items taken from this series of frogs include 9 orders of insects, as follows: HYMENOPTERA, 21 ants, 4 wasps and 2 sweat bees; ODONATA, 1 dragon fly and 3 nymphs; COLEOPTERA, 1 scarab, 4 hydrophilids, 5 staphylinids, 6 carabids, 1 weevil, 2 tumble-bugs, 6 ladybirds, 1 grub, 1 dytiscid, 4 tiger and 18 unidentified beetles; HEMIPTERA, 2 marsh treaders, 1 belostomid, 3 gerrids, 1 squash and 2 unidentified bugs; DIPTERA, 2 blue-bottles; 9 mosquito larvae, 1 horse fly, 4 crane flies, 2 gnats, 1 syrphid, 2 dipteran larvae and 15 unidentified adults; HOMOPTERA, 1 aphid; LEPIDOPTERA, 5 caterpillars; ORTHOPTERA, 4 grasshoppers; EPHEMERIDA, 2 may-fly nymphs; TRICHOPTERA, 1 caddis-fly. Other animals include: ARACHNIDA, 15 spiders; CRUSTACEA, 1 crayfish and 1 sow-bug; DIPLOPODA, 1 millipede; AMPHIBIA, 1 tadpole; MOLLUSCA, 1 *Physa*, 1 *Lymnaea* and 1 terrestrial slug (*Agriolimax*).

Thus, arthropods constitute 97.5% of the diet; insects form 86.3%, arachnids 9.4%, crustaceans 1.2%, millipedes .6%, tadpoles .6% and mollusks 1.9%.

Bufo boreas boreas (Baird and Girard).—The northwestern toad is widespread throughout the northwestern part of the United States. Most of the thirty-two specimens examined from Oregon came from relatively high altitudes: 23 were taken in the Granite Mountains at an elevation of about 8,000 feet; 8 came from Fish Lake, above Halfway, and 1 from near Wallowa Lake. In the higher mountains, such as the Granites, the male toads congregate in pools in the alpine meadows even before the ice is entirely gone, about the middle of June. These males have not taken food in the quantities that are to be found in the stomachs of females. At this time, the females are found on the drier slopes and in the patches of nearby forest. They eventually join the males at the breeding sites. At Lake Cushman, on the Olympic Peninsula, Washington, in the middle of August, young toads metamorphose at a length of about 1.5 cm. In 1935, the numbers of young toads on the shore was so great that one could not step from a boat without crushing some of them. The shallows along the shore were still black with tadpoles. After the breeding season in June, toads of the mountains scatter widely and although they may be collected over a wide area, each shows a preference for beetles and ants.

Analysis of 32 stomachs yields the following list: ARACHNIDA, 12 spiders; CRUSTACEA, 1 crayfish and 1 sow-bug (both items from a specimen taken at a lake); HYMENOPTERA, over 159 ants (one female contained 50); COLEOPTERA, more than 85 unidentified beetles or parts, 2 ladybirds, 3 elaters, 1 weevil, 25 bark beetles, 2 grubs, 35 tiger beetles, 6 staphylinids, 26 carabids and 2 scarabs (one female contained 30 beetles); LEPIDOPTERA, 1 caterpillar; DIPTERA, 1 mosquito; ORTHOPTERA, 3 grasshoppers; TRICHOPTERA, 1 caddis-fly.

Thus the diet consisted of 100% arthropods, with insects 96.2% of the total. Ants formed 43.5% and beetles 51.1% of the total, while the remainder was made up of 1.6% of other insects, 3.3% of spiders and .5% of crustaceans.

Sceloporus occidentalis occidentalis (Baird and Girard).—One specimen, taken in brush at the base of a pine, *Pinus contortus*, near Bend, Oregon, contained 5 beetles and 1 spider, and was infected with 12 ascarids. Of 5 specimens examined in semi-arid country near O'Brien, Oregon, all contained ants and grasshoppers, 2 contained beetles, and 3 of the 5 were parasitized by ascarids.

Coluber constrictor mormon (Baird and Girard).—One specimen, taken in sagebrush desert in Richland County, Oregon, contained only grasshoppers.

Thamnophis sirtalis concinnus (Hallowell)—One specimen, taken in Seattle, Washington, contained 12 slugs (*Agriolimax* sp.). Another, from near Lake Cushman, Olympic Peninsula, Washington, contained 1 *Ascaphus truei*.

Thamnophis ordinoides vagrans (Baird and Girard).—Five specimens, taken in July along streams near Wallowa, Oregon, were semi-aquatic in habit. One from the bank of a stream had eaten 13 slugs (*Agriolimax* sp.), while each of the other 4 specimens contained bullheads, one of which was 3½ inches long.—CLINTON F. SCHONBERGER, *16 Avenue 53, Venice, California*.

A LEUCISTIC SPECIMEN OF THE BLACK SALAMANDER.—On December 25, 1944, while collecting salamanders in a grassy meadow at Cummings, Mendocino County, California, I found two specimens of the black salamander, *Aneides flavipunctatus* (Strauch), under a board. Both were active, although the day was cool. One was of normal black color, like others found in the vicinity, but the other appeared to have no pigment except in the eyes, which were normal. This leucistic specimen was translucent white tinged with pinkish from the blood. The viscera could be seen through the dorsal body wall as well as through the ventral surface. After the specimen was preserved in formalin many minute spots became visible, although the whitish ground color was still predominant. The spots were most abundant on the dorsal surface, but some were present on the ventral surface of the tail, near the anus, and on the chin. They were entirely absent only on the midventral surface.

Under microscopic examination the pigment spots appeared to be melanophores. Most of them are in the contracted state forming irregular black spots .05 to .10 mm. in diameter, while others are in the expanded amoeboid shape and are pale gray in color.

The total length of the leucistic specimen was 50 mm. and the body length was 30 mm. The specimen, as No. 40730, is preserved in the Museum of Vertebrate Zoology.—LILLIAN M. SEELIGER, *Museum of Vertebrate Zoology, Berkeley, California.*

NOTES ON *SCELOPORUS UNDULATUS UNDULATUS*.—Data on the size of young and on the feeding habits of *Sceloporus undulatus undulatus* were obtained during two collecting trips along a 2.2 mile strip of a 10-foot wide, dusty country road bordered by abandoned farm land with scattered patches of oak-hickory forest. This road is approximately 6 miles east of Carbondale, Illinois, and 2 miles south of Crab Orchard Lake. All lizards were collected from the road and a 5 to 10-foot strip immediately adjacent. Collecting procedure was simple. A collector rode on each front fender of a car as it was driven slowly down the road. When the basking lizards were disturbed, they would make short runs and the collectors could pursue them.

On the first trip, August 28, 1941, 58 of 87 lizards observed were collected. Of these 58, 6 were mature females and 52 were juveniles. The 6 females ranged from 64 to 89 mm. in body length, mean 73; the juveniles ranged from 22 to 43 mm., mean, 30.

Many of the juveniles had recently hatched, as evidenced by their size and the condition of the umbilical scar. Others were apparently several weeks old. Twenty of the juveniles were preserved immediately and the stomachs subsequently examined. These contained the remnants of 362 ants, 16 spiders, 4 grasshoppers, 4 wood roaches, 6 leaf hoppers, 7 small moths, several beetles, 6 caterpillars, 1 fly, and numerous fragments of white material tentatively identified as ant pupae. One stomach contained the remains of 33 small ants.

A second trip, made September 11, yielded 23 of 50 individuals observed. A single male and female were collected; the remainder were juveniles ranging in length from 26 to 45 mm., mean 35. The narrow range of juvenile measurements indicates that hatching occurs over a short period of time in this section.—FRED R. CAGLE, *Peterson Field, Colorado Springs, Colorado.*

THE SPADEFOOT TOAD IN ILLINOIS.—On March 10, 1942, while spading in the loose dirt on the island in Horse Shoe Lake, Alexander County, Illinois, I turned up a small toad with peculiar large horny tubercles at the base of each rear foot. The golden iris of the eye and slit-like, vertical pupil made me realize this was a totally unfamiliar species. The only reference at hand was Wright and Wright, "Handbook of Frogs and Toads." While this made simple the determination of the species as *Scaphiopus holbrooki holbrookii*, it did not indicate that the species was new to Illinois, for the range therein is, "Massachusetts to Florida, west to Texas and Arkansas." Therefore, I did not hasten to preserve the specimen but attempted to keep it alive, driving north with it several days later. Upon arriving at Chicago I found the toad had died and was quite liquified, and, therefore discarded it. It was not until several months later upon receiving Cagle's "A Key to the Reptiles and Amphibians of Illinois" that I realized I had failed to preserve the first specimen of the species taken in Illinois.—WM. H. ELDER, *Illinois Natural History Survey, Urbana, Illinois.*

Reviews and Comments

REPTILIA AND AMPHIBIA, Vol. III.—Serpentes. By Malcolm A. Smith, *in* The Fauna of British India, Ceylon, and Burma, including the whole of the Indo-Chinese Sub-region. Taylor and Francis, London 1943: XII + 583, 1 map, 166 text figs. £ 2-5-0. —The appearance of the third volume of Malcolm Smith's monumental work in the Fauna of British India is a major event in herpetological circles. It completes the treatment of the reptiles, leaving the frogs, salamanders, and caecilians for a fourth volume. The whole work will summarize a half century's progress in the study of the amphibians and reptiles of the Oriental fauna, replacing Boulenger's single volume of 1890. It is an extraordinary satisfaction to have at hand so complete and competent a faunal work for one of the major zoogeographic regions, for such a work affords a secure foundation for even more important studies of the life histories and interrelations of animals, which cannot be made until the taxonomic framework is adequately established.

Dr. Smith has had the great majority of the museum collections of Oriental snakes available for study and examination, including those of the British Museum, the Indian Museum, the Bombay Natural History Society, with his own extensive Siamese material. One of the principle taxonomic merits of the work lies in the review of the species described by Bourret in his various publications, as Dr. Smith was fortunately able to see the Bourret types in Paris. The contributions of Colonel Wall to our knowledge of the Indian snake fauna are rightly emphasized.

Much of the immediate interest of the new volume to American zoologists lies in Dr. Smith's contributions to the anatomy of the snakes, and especially to the comparative anatomy of the families. While his attention has been directed especially to peculiarities of the Oriental genera, his introduction, which occupies 38 pp., with a special bibliography of 45 titles, is of interest to every herpetologist. His accounts of the glands of the head and of the curious dorsal glands may be especially mentioned. There are numerous figures of the maxillary apparatus, hemipenes, and of other structures in the systematic section.

Dr. Smith's arrangement of the families and subfamilies is of especial interest. He gives up entirely the subfamilies Pythoninae and Boiginae, retains the Dipsadinae, and unites *Elachistodon* with *Dasypeltis.* The total of species, exclusive of subspecies, in the fauna in question amounts to 389, in the following arrangement:

	Number of Genera	Number of Species
Typhlopidae	1	19
Leptotyphlopidae	1	2
Uropeltidae	7	44
Anilidae	1	2
Xenopeltidae	1	1
Boidae	2	4
Colubridae (55 genera, 235 species)		
Dipsadinae	2	6
Xenoderminae	4	4
Achrochordinae	1	2
Colubrinae	40	204
Homalopsinae	8	19
Dasypeltidae	1	1
Elapidae	3	21
Hydrophidae	12	29
Viperidae (7 genera, 31 species)		
Viperinae	5	7
Crotalinae	2	24

The reviewer prefers the style of description in the present work to the cumbersome and over-meticulous descriptions of single specimens in vogue in much American herpetology. The resemblance to the Boulengerian form, almost startling on opening the volume, is unnecessarily preserved in the keys, in which little attempt at dichotomy is made; and in a work containing so large an original contribution, the number of specimens on which the inclusive scale counts are based would have been a valuable datum. The statement of geographic ranges is frequently in much too general terms. The subordination of subspecies, so that they do not appear in the numbered list, constitutes a

logical form, and is especially to be commended in a fauna in which our knowledge of the subspecific categories is very uneven. Dr. Smith employs a useful convention in his synonymies, in which the scientific name is separated by a comma from the author's name except for the describer of the species. The names of the authors of species are not incorporated in the species headings, thus avoiding both the convention of parentheses and the revolt against it. The resulting form is typographically simple and pleasing. Many of the nomenclatorial changes of recent years are followed and there are a number of new changes of familiar generic names. The retention of the spelling *Ancistrodon* for the familiar genus of pit-vipers is justified on the basis of an action of the International Zoological Congress of 1930; the reviewer is in sympathy with this, but for totally unrelated reasons, and it is to be regretted that so large a synonymy should have been permitted to grow up for the spelling *Agkistrodon* during the past fifteen years. One might wonder if all generic names not correctly latinized are to be subject to change.—Karl P. Schmidt, *Chicago Natural History Museum, Chicago, Illinois.*

REPTILES AND AMPHIBIANS OF MINNESOTA. By W. J. Breckenridge.—The University of Minnesota Press, Minneapolis, 1944: xiii + 202 pp., 52 figs. 45 maps, $2.50.—Herpetologists have long awaited an account of Minnesota's reptiles and amphibians because, geographically speaking, this state occupies a strategic area including the transition zone between prairie and forest as well as 5.5 degrees of latitude in which severity of climate progressively reduces the herpetological element of the fauna. It is not surprising that the state lies well within the ranges of only two among its forty-five species, there being but one snake and one frog with a range that is not in part delimited by Minnesota or by territory barely beyond its boundaries. The use of the phrase "westward to Minnesota," so often in the past based only on assumption, may now be amply vindicated.

Reptiles and Amphibians of Minnesota takes its place with the few other excellent state reports. The outstanding features are a thorough consideration of the literature and collation of it with valuable original investigation by the author; clear distributional maps, one for each species; numerous good illustrations properly distributed through the text; accurate descriptions and accounts of habits; adequate and interesting introductory sections, including six pages by Milton Thompson on the care of captives. The book ends in an index, which is preceded by a bibliography and a glossary.

Headings are granted only to full species, the status of all subspecies being discussed in special opening paragraphs. This may well be the simplest method for a strictly regional work, although complications arise in the small insert maps showing, in most cases, total species ranges; laymen no doubt will be confused, but then the subspecies concept is inherently confusing to them. Ranges are quoted largely from Stejneger and Barbour (1943), again a procedure that may be best, although it perpetuates certain errors.

In an effort to be thorough, the author has quoted where paraphrasing would have sufficed, and given long rather than short descriptions. If an amateur, with specimen in hand, reads a description he is helped only by diagnostic characters and comparative statements. Six lines often accomplishes the purpose when a full page would merely confuse. The professional herpetologist seldom relies on semi-popular descriptions based on geographically restricted material, whereas the layman would rather identify his specimen easily and quickly, then see with his own eyes what it looks like. I have found Carr's *Herpetology of Florida* a most useful state report in spite of the extreme brevity of its descriptions; such brevity is actually an asset. This criticism is not aimed specifically at the present work, which merely follows an unfortunate precedent. Much paper, ink, and time can be saved by giving carefully constructed diagnoses rather than long, blanket descriptions.

These are among the few erroneous statements: snakes have no eyelids; water is drawn in through the nostrils of tadpoles. Also I find the following inconsistency: family arrangement is given for the frogs only.

References to illustrations were omitted from species headings, although some illustrations are separated from the accounts of their species.—Clifford H. Pope, *Chicago Natural History Museum, Chicago, Illinois.*

SOME CONSIDERATIONS ON THE DISTRIBUTION OF FISHES IN ONTARIO. By Isobel Radforth. *Contr. Roy. Ont. Mus. Zool.*, 25: 1–116, figs. 1–32. 1944.—"This paper is an attempt to describe the distribution of Ontario fishes and to offer feasible explanations for their dispersal." As such it is the second critical analysis of Postglacial redistribution of fishes into a major area of the glaciated region of North America (the first, Greene's "The Distribution of Wisconsin Fishes," 1935). Since Ontario extends from Hudson Bay to Lake Erie, and from the St. Lawrence River to the Lake of the Woods, it received fishes through all major glacial connectives from the Warren Outlet of Lake Agassiz to the Hudson. Thus, the province is admirably situated for this study.

The distributional account is prefaced by a concise, readable, and adequately illustrated summary of the glacial lake history of the entire area. Instead of following the conventional phylogenetic sequence, the species are considered in 12 groups, most of which are characterized by a similar distributional pattern of the several species and by a common Postglacial dispersal.

The three principal centers of Postglacial dispersal considered are the Alaska-Yukon area, the upper Mississippi Valley, and the Atlantic coastal plain. Of these the Mississippi is held to have contributed the most. A few forms have been established through human introduction. Several, of marine derivation, are indicated as having entered by way of the St. Lawrence waterway, but none is listed as an exclusive entrant from Hudson Bay. Ecological factors have proved important in limiting the distribution of many forms within the province: the 65° F. and 70° F. July isotherms seem especially significant since they coincide roughly with the northern limits of many species; other forms are limited to deep cold waters or to clear cool streams. Some forms have gained access to Ontario from both the upper Mississippi basin and the Atlantic coastal plain, and in a few species (e. g., *Rhinichthys atratulus, Fundulus diaphanus*) two subspecies have become established, one from the west, the other from the east.

In order to determine the center of Postglacial dispersal for any species it is essential to know its approximate distribution during glacial time. In the reviewer's opinion Mrs. Radforth has, for the most part, interpreted these glacial patterns of distribution logically and as accurately as the subject matter would permit, with one exception. It is apparently rather generally believed that species which occur at present east of the mountains south to Virginia were resident on the Atlantic slope during glacial times, and Mrs. Radforth very understandably regarded this area as one source of redispersal for these species into Ontario. The Postglacial invasion of fishes from the Great Lakes into the Hudson River system by way of the Mohawk outlet is widely recognized. Glacial lakes Watkins and Newberry in the present Fingerlakes Region of New York discharged to the south into the Susquehanna River by way of the Horseheads Outlet (Fairchild, 1934, Bull. Geol. Soc. Amer., 45: 1073–1110). In the exhaustive studies of the New York Biological Survey, Greeley recorded at least 19 species in the upper Susquehanna watershed which were not taken in the Delaware system. It is significant that all except *Coregonus clupeaformis* occur in the upper Mississippi basin, and 12 of them live in the Hudson River system. These data are taken as strong evidence that the Horseheads Outlet provided ingress to the Susquehanna system for some species (some Great Lakes forms found in the Susquehanna system are absent from the upper Ohio basin; thus, stream capture from that source fails to supply a tenable explanation). Since ocean levels were much lower during the Pleistocene than at present, it seems probable that fresh-water fishes could formerly move freely from one stream to another in the region of the present shallow Chesapeake embayment, especially during periods of maximum discharge from glacial waters and precipitation. If this assumption is correct it would appear that the occurrence of a species even as far south as the James River, Virginia, does not prove that it was resident on the Atlantic slope in glacial time. Species which occur natively in the Roanoke, Delaware and Connecticut rivers were not affected by major glacial outlets (although some northern types such as *Catostomus catostomus* and *Couesius* gained access into one or more of them), and their faunae are characteristically eastern. Among the fishes interpreted by Mrs. Radford as having entered Ontario from both the Atlantic coastal plain and the upper Mississippi system, but which I regard as more probably of purely Mississippi basin origin, are *Nocomis micropogon, Notropis h. hudsonius, N. rubellus, N. spilopterus, Clinostomus elongatus, Hyborhynchus notatus,* and *Percina caprodes.*

The reviewer's chief criticism of this excellent work pertains to the method of presentation of distribution records. Locality records for the various species are given only on maps. Although a very acceptable method in principle, this procedure calls for good base maps and clarity in reproduction. The base maps show very few streams and lakes, and the Hudson Bay-Great Lakes drainage divide is not indicated. Numerals are plotted instead of the more conventionally used symbols, and because of the great reduction they are read with difficulty—a few being wholly illegible. As many as 18 (usually 3 to 5) species are plotted on a single map, and since forms of similar distribution are associated the result is a maze of numbers which conveys almost no visual picture of the range of the individual species. In Figure 29 the legends for *Amphiodon alosoides* and *Hiodon tergisus* were inadvertently transposed.

As a major contribution to the dynamics of zoogeography, Mrs. Radforth's treatise will be of importance to zoogeographers and ichthyologists alike. The text is clear, well written and edited, and includes an extensive bibliography and an index.—Reeve M. Bailey, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

GUIDE TO HIGHER AQUARIUM ANIMALS. By Edward T. Boardman. Bull. Cranbrook Inst. Sci., 21, 1944: 1–107, 59 figs. $2.00.—This attractive little book is a companion volume to the author's "Field Guide to Lower Aquarium Animals." It is intended for amateurs interested in maintaining home or school aquaria or terraria. A selected list of 59 species of Michigan animals (30 fishes, 18 amphibians, and 11 reptiles) is discussed. Consideration is given to their distinguishing features, habitat, food habits, reproductive behavior, and requirements in captivity. Most of the species are illustrated by excellent photographs. Appendices include a short list of exotic aquarium fishes, suggestions regarding water supply for the aquarium, and a brief consideration of disease treatments. There is a well chosen bibliography of 24 titles.

This is manifestly a book for beginners; neither the experienced aquarist nor the professional zoologist will linger long over its pages. The style is pleasing and informative for the amateur, although it seems to the reviewer that too much space is devoted to characteristics and natural history and too little to maintenance in the aquarium. The use of the metric system in expressing lengths of animals appears to place an unnecessary chore of translation on the lay reader. The text is reasonably free from errors, and the nomenclature is up to date although marred by misspellings. *Lepisosteus productus* is called shortnose gar (*L. platostomus*) instead of spotted gar. A beautiful photograph of *Ambystoma tigrinum* is used to depict *Ambystoma maculatum*.—Reeve M. Bailey, *Museum of Zoology, University of Michigan, Ann Arbor, Michigan.*

LITERATURE RECEIVED

The Geckoes of the Genus *Coleonyx* with Descriptions of New Subspecies. By Laurence M. Klauber. Trans. San Diego Soc. Nat. Hist., 10 (11), 1945: 133–216, 2 maps.

A Preliminary Analysis of the Herpetofauna of Sonora. By Charles M. Bogert and James A. Oliver. Bull. Amer. Mus. Nat. Hist., 83, Art. 6, 1945: 303–425, 8 plates.

The Natural History and Morphology of Amphiumae. By C. L. Baker. Report of the Reelfoot Lake Biological Station, 9, 1945: 55–91, 13 figs. Reprints furnished to interested persons upon request.

EDITORIAL NOTES AND NEWS

Honor Roll

ADDITIONS to and changes in the list of Society members in the U. S. armed services are: ENSIGN E. C. ASH, U. S. Navy; BENJAMIN BANTA, U. S. Army; PFC. HARRY B. BECHTEL, Army Air Corps; CAPT. ALBERT P. BLAIR, Army Air Corps; LT. JAMES A. SLATER, U. S. Navy; PFC. HOWARD CADWELL, Army Medical Corps; PFC. ROBERT E. COBURN, Parachute Infantry; LT. EDWARD E. DORSON, Army Air Corps; LT. HERNDON G. DOWLING, U. S. Marine Corps; PVT. IRWIN L. FIRSCHIEN, U. S. Army; LT. COL. F. G. HALL, Army Air Force; PVT. GEORGE H. HANLEY, U. S. Army; LT. G. Y. HARRY, U. S. Navy; PVT. MAX HECHT, U. S. Army; A/S HENRY HILDEBRAND, U. S. Navy; ENS. E. W. JAMESON, U. S. Navy; SGT. R. M. KNOX, U. S. Marine Corps; RICHARD B. LOOMIS, U. S. Navy; CPL. EDMOND MALNATE, U. S. Army; SGT. LAWRENCE F. MILLER, U. S. Army; LT. MALCOLM V. PARKER, U. S. Army; LT. L. EDWARD PERRY, Public Health Service; LT. THOMAS REICHELDERFER, U. S. Coast Guard; PFC. EMIL J. ROKOSKY, Army Medical Corps; PFC. NEVIN S. SCRIMSHAW, U. S. Army; MAJ. G. H. SOULEN, U. S. Army; CAPT. CLARENCE M. TARZWELL, Public Health Service; PFC. LAWRENCE D. TOWNSEND, Army Medical Corps; CPL. ERNEST E. WILLIAMS, Army Medical Corps.

News has just been received that PVT. EDWIN H. SINCOCK, JR., who had been a member of the Society since 1943, was killed in Germany in November, 1944.

A recent number of the *Stanford Alumni Review* gives an account of the dramatic adventures of SGT. JOHN LESLIE HAWKEN, who was last reported in our Honor List as a prisoner on Bataan. A student in languages and biology at Stanford, Sgt. Hawken enlisted in the Army in the summer of 1941, and was sent to the Philippines, where, as supply sergeant in the Signal Corps, he was evacuated from Manila, and fought through the battles of Bataan and Corregidor. After the fall of the latter he managed to escape from the enemy, and spent the next thirty months in the hills. He found his ability with languages an asset in picking up the Tagalog and scraps of other Philippine dialects, and his interest in snakes another asset in keeping him alive. He ate python stew and cobra soup, and managed to preserve a reptile collection. When the Americans invaded Luzon, he was sent back to an Australian hospital for a month of recuperation, and then returned home. Sgt. Hawken wears two Presidential Unit Citations, an Oak Leaf Cluster for the defense of Bataan, the Good Conduct Medal, American Defense Medal with bronze star and the Asiatic Theater ribbon with bronze star.

News Notes

A CABLEGRAM received by DR. CARL L. HUBBS, from HONORARY FOREIGN MEMBER PETER J. SCHMIDT, announces the good news that he and his scientific associates are safely back in Leningrad. Their address is Zoological Museum, Academy of Sciences, Leningrad, U.S.S.R.

On January 1, 1945, DR. GORDON GUNTER, who for the past five and a half years has been Marine Biologist for the Texas Game, Fish and Oyster Commission, was appointed Research Associate in the newly established Institute of Marine Science, of the University of Texas. JOEL W. HEDGPETH, of Walnut Creek, California, has taken over Dr. Gunter's duties in the Game, Fish and Oyster Commission.

DR. NORMAN E. HARTWEG and DR. WILLIAM H. BURT, of the Museum of Zoology, University of Michigan, are making a three month's study of the effects of volcanic activity on the vertebrate animal life in the vicinity of the Mexican volcano Paricutin.

DR. ARCHIE CARR has been granted a three to six years' leave by the University of Florida to join the staff of the Escuela Agricola Panamericana, the school recently established by the United Fruit Co. in Honduras, under DR. WILSON POPENOE, to train boys chosen on scholastic ability from the Latin American republics, in the best farming prac-

tices. Dr. Carr will teach biology, make a reconnaisance survey of the vertebrates of the region, and continue his studies on the difficult turtle problems of Central America.

Earl Desmond Reid Retires

THE many friends of EARL DESMOND REID, in the National Museum, Washington, D.C., gave him a farewell party on the afternoon of February 28, 1945, in the Division of Fishes, in honor of his 29 years and 4 months service with that institution.

Earl D. Reid, born February 14, 1885, near Mendon, Michigan, began work under the United States Civil Service as watchman at the National Museum on October 23, 1915, and resigned to accept a clerkship in the Division of Fishes on January 1, 1918. He became scientific aid on August 1, 1925, and on July 16, 1938, was made Senior Scientific Aid, retiring February 28, 1945.

The road that led Mr. Reid into ichthyology was a hard one. His whole life was greatly influenced by enlisting in the United States Marine Corps, January 11, 1907. In February, 1911, he was selected for special assignment and was sent to Bluefield, Nicaragua, near where he received severe injury in line of duty resulting in complete blindness. Mr. Reid was returned to the U.S. Naval Hospital at Washington, and regained partial vision after more than a year of confinement in total darkness. He was honorably discharged on May 14, 1912.

Undoubtedly if his eyesight had not been impaired from gun powder burns he would have been engaged in more physically active work and thus ichthyology would have lost the man who really kept the fish collection in the National Museum in a good state of preservation for nearly 25 years. He became imbued with the scientific spirit of research and investigation, no doubt from contact with numerous visiting ichthyologists at the Museum during the 1920's, and this led him to work up and to publish 14 papers on fishes either alone or as co-author.

During his services as Scientific Aid and Senior Scientific Aid he spent much time examining fishes for out-of-town investigators, sending his observations to them. Thus most of the ichthyologists in North America and several in foreign lands were aided. In recognition of his service his name appears in numerous paragraphs of acknowledgment in many scientific papers. Five fishes and one mite have been named in his honor as follows: *Pomacentrus reidi* Fowler and Bean; *Diaphus reidi* Fowler; *Hippocampus reidi* Ginsburg; *Uropterygius reidi* Schultz; *Noemacheilus reidi* H. M. Smith; and *Haemogamasus reidi* Ewing.

In addition to his keen interest in ichthyology he possesses special mechanical ability along with a fertile mind for developing mechanical devices. During my associations with him since December, 1936, he has brought to the laboratory more than half a dozen devices, made in his basement workshop in his home, that facilitated the work in the museum. The most important devices were for removing the glass tops from the jars containing alcoholic fishes, and a device for spreading or opening the mouths of fishes.

At the time of his retirement he had assembled several hundred otoliths of a large number of species of fishes. This enabled him, along with the skeleton collection, to make identifications of bone fragments that came into the National Museum in considerable quantities. Indeed, he excelled in this work and is an expert with fish skeletons. Most of the routine burdens of taking care of the fish collections and cataloguing incoming collections were done by him.

During the past few years his failing eyesight gradually became worse, so he decided to retire at the age of 60 years and do the many things that he had hoped to have time for in his leisure. His many ichthyological friends appreciate greatly his faithful services and extend to him their best wishes for the many years of leisure that he deserves.—LEONARD P. SCHULTZ, *United States National Museum.*

Announcements

THE editors acknowledge with gratitude the financial aid received from the GIFT FUND of the Society and from the UNIVERSITY OF CINCINNATI in publishing this issue of COPEIA.

DR. LEONARD P. SCHULTZ, Curator of Fishes, U. S. National Museum, Washington 25, D. C., is looking for someone to fill the position of Scientific Aid left vacant by the retirement of Mr. E. D. Reid. Anyone interested should get in touch with Dr. Schultz at the above address.

COPEIA IS THE JOURNAL OF THE AMERICAN SOCIETY OF ICHTHYOLOGISTS AND HERPETOLOGISTS

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